Optimal Social Assistance and Unemployment Insurance in a Life-Cycle Model of Family Labor Supply and Savings

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Abstract

We analyze empirically the optimal mix and optimal generosity of social insurance and assistance programs. For this purpose, we specify a structural life-cycle model of the labor supply and savings decisions of singles and married couples. Partial insurance against wage and employment shocks is provided by social programs, savings, and the labor supplies of all adult household members. We show that the optimal policy mix focuses mainly on social assistance, which guarantees a permanent universal minimum household income, with a minor role for temporary earnings-related unemployment insurance. Optimal social assistance is moderately generous. Reflecting that married couples obtain intra-household insurance by making labor supply choices for both spouses, we also show that the optimal generosity of social assistance is decreasing in the proportion of married individuals in the population.

Key Words: Unemployment insurance; Social assistance; Design of benefit programs; Life-cycle labor supply; Family labor supply; Intra-household insurance; Household savings; Employment risk; Added worker effect.

JEL Classification Codes: J18; J68; H21; I38.

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1 Introduction

In many countries, the 'social safety net' combines unemployment insurance with social assistance programs: broadly speaking, unemployment insurance provides temporary earnings-related benefits to newly unemployed individuals, while social assistance programs guarantee households a permanent universal minimum income. Interestingly, the overall generosity of the social safety net and the relative importance of unemployment insurance and social assistance programs vary considerably across counties. In the United States, unemployment insurance provides earnings-related income replacement, but assistance benefits are markedly less generous and thus social support falls considerably when unemployment insurance benefits are exhausted. In contrast, in the United Kingdom essentially all social support is provided through social assistance: income replacement is universal, stable and moderately generous. Many continental European countries, including France and Germany, combine the two systems: unemployment insurance provides temporary earnings-related benefits and social assistance programs guarantee all households a moderate to generous minimum income.[1]

These large differences across countries in the design of the social safety net suggest that there is little consensus about how to best combine unemployment insurance and social assistance. This motivates the first contribution of this paper, which is to provide empirical evidence about the optimal mix and optimal generosity of unemployment insurance and social assistance. In doing so, we extend previous studies that analyze the optimal design of unemployment insurance or social assistance programs in isolation, e.g., Hopenhayn and Nicolini (1997), Saez (2002), Chetty (2006) and Shimer and Werning (2008). It is important to consider the optimal design of unemployment insurance and social assistance jointly, most obviously because social assistance provides an income floor that affects the moral hazard and insurance effects of unemployment insurance.

When considering the optimal design of unemployment insurance and social assistance, it is crucial to account for interactions between the insurance provided by the social safety net and the intra-household insurance available from labor supply and savings: neglecting intra-household insurance will overstate the insurance value of the social safety net and will thus bias upwards the optimal generosities of unemployment insurance and social assistance. The literature has typically considered the design of social insurance or social

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[1]The OCED tax-benefit model calculates the net replacement rate (ratio of benefits to previous after tax earnings) for those in the initial phase of unemployment and those in long-term unemployment (see OECD, 2015). In 2014, single individuals without children who previously earned the average wage and who qualified for social assistance had an initial replacement rate of 59% in Germany, 45% in the US, and 38% in the UK. In contrast, the long-term replacement rates for the same groups were 38% in the UK, 35% in Germany, and only 6% in the US. Differences between countries and by the duration of unemployment are similar for other household types (e.g., married households and households with children).

assistance programs in the presence of intra-household insurance from savings and a single source of labor supply (and thus earnings). This paper makes a second contribution by exploring the optimal design of unemployment insurance and social assistance programs when households have an additional means of intra-household insurance. Specifically, we recognize that couples make labor supply choices for both spouses–a so-called family labor supply decision (Blundell et al., 2016b)–and we derive the optimal combination of unemployment insurance and social assistance in the presence of intra-household insurance from family labor supply.

Our decision to consider the optimal design of the social safety net in the presence of family labor supply is motivated by research showing that married couples obtain insurance by adjusting one spouse's labor supply in response to employment and wage shocks affecting the other spouse. Lundberg (l985) finds an 'added worker effect' whereby women increase their own labor supply when their husbands' earnings decline.[2] Blundell et al. (2016b) show that permanent shocks to an individual's wage are largely insured by adjustments of the individual's own labor supply combined with adjustments of the spouse's labor supply, and Cullen and Gruber (2000) find that the labor supply of wives decreases as the generosity of their husbands' unemployment insurance benefits increases.

We explore the optimal combination of social assistance and unemployment insurance in the presence of intra-household insurance from family labor supply by embedding a social insurance and assistance system in a dynamic structural model of life-cycle labor supply and savings decisions. The model includes: i) a labor supply choice for both members of a married couple, which recognizes that family labor supply may provide intra-household insurance that substitutes for insurance from social insurance and assistance programs; ii) between-spouse leisure complementarities, which may moderate the response of a spouse's labor supply to his or her partner's job loss; iii) liquidity constraints that limit the ability of households to self-insure by dis-saving; iv) heterogeneity in education, which generates a redistributive motive for social programs; and v) search decisions and endogenous quits, both of which may be subject to moral hazard effects from social assistance and unemployment insurance. The model further includes wage risk and employment risk, which generate demand for insurance.

The parameters of the model are estimated using indirect inference applied to a panel sample of singles and married couples taken from the German Socio-Economic Panel (SOEP). The estimated model has good in-sample fit. The estimated model also replicates existing reduced-form results. For example, we show that the estimated model

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[2]Triebe (2015) replicates this finding using a similar sample to ours from the German Socio-Economic Panel (SOEP). Added worker effects may be driven by nonseparabilities between the spouses' leisure times (Goux and Petrongolo, 2014) or by a preference for income replacement. Importantly, both leisure-driven and income-driven added worker effects imply that the family labor supply decision of married couples is relevant to the optimal design of social insurance and assistance programs.

implies that a one-week increase in the initial entitlement period increases the duration in non-employment by 0.1–0.2 weeks, which is in line with the previous literature (e.g., Lalive et al., 2006, and Schmieder et al., 2012). We take the consistency of the model with previous findings as evidence that the model is well-suited to analyzing questions surrounding the design of social assistance and unemployment insurance.

Based on the estimated model, we find that the optimal policy mix focuses on permanent universal social assistance, with little or no role for temporary earnings-related unemployment insurance; in this assistance-orientated system, individuals who recently left employment receive a similar level of social support to those in long-term unemployment. We also find that the optimal generosity of social assistance is lower than the prevailing level in Germany but is moderately generous by international standards. Overall, the optimal social support system resembles the UK system, in which essentially all social support is provided through social assistance. Interestingly, we find that the desirability of an assistance-orientated system applies irrespective of the distributions of marriage and education in the population, and therefore this finding is not driven by education-based redistributive concerns or by factors that are specific to married couples. Our results also show the importance of studying jointly the optimal design of unemployment insurance and social assistance. In particular, while unemployment insurance has little or no role in the optimal mix, we find that unemployment insurance with a replacement rate of 20% is optimal when social assistance provides limited support.

We also find that the optimal generosity of social assistance within the optimal policy mix depends strongly on the population share of married couples. Relative to a population of single individuals, the presence of the empirically observed proportion of married couples in the population reduces the optimal generosity of social assistance by 12% in high-educated populations and 18% in low-educated populations. We show that the dependence of the optimal program on the presence of married couples in the population is related to family labor supply. In particular, we find that couples optimally increase one spouse's labor supply in response to the other spouse's job loss, which shows that family labor supply provides intra-household insurance to couple households. We also find that marriage becomes more important to optimal program design as education decreases, which is consistent with intra-household insurance from marriage being most valuable to low-educated individuals (who have relatively high employment risk and low wages).

This paper builds on previous work that has linked optimal program design with empirical estimates of the effects of social insurance and assistance programs on consumption smoothing, search and savings decisions. Gruber (1997) explores how the optimal unemployment insurance replacement rate depends on the effect of unemployment insurance on consumption smoothing and search. Chetty (2008) emphasizes the role of liquidity constraints in driving the optimal provision of unemployment insurance, and Lentz (2009) shows that the optimal unemployment insurance replacement rate decreases with house-

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hold wealth; the important role for intra-household insurance from savings suggests that intra-household insurance from family labor supply may also be policy relevant. Our results also add to research that emphasizes program interdependencies (see Keane and Moffitt, 1998, and Chan, 2013), and to a growing literature that makes comparisons between insurance-based and assistance-based social programs (see Low et al., 2010, Low and Pistaferri, 2015, and Saporta-Eksten, 2014).[3]

Methodologically, our approach shares some features with other studies based on structural life-cycle models. In particular, our model follows the literature in how it captures interactions between the contemporaneous incentives presented by social insurance and assistance programs and the intertemporal incentives to accumulate human capital (see, e.g., Keane and Wolpin, 1997, Imai and Keane, 2004, Keane, 2015, Blundell et al., 2016a and Adda et al., 2017). We also follow the literature in how we model incentives to accumulate entitlement to social insurance programs (see, e.g., French, 2005, Attanasio et al., 2008, Low et al., 2010, and Heathcote et al., 2014).[4]

This paper proceeds as follows. Section 2 describes our life-cycle model. Section 3 describes the SOEP survey and our estimation sample. Section 4 outlines the indirect inference estimation procedure. Section 5 presents the structural parameter estimates and explores the fit of the model. Section 6 reports our results on the optimal mix and optimal generosity of social assistance and unemployment insurance. Section 7 concludes.

2 Life-cycle Model

We propose a discrete-time dynamic model of the labor supply and savings decisions of singles and married couples over the life cycle. Section 2.1 provides an overview of the model. We then describe preferences (Section 2.2), the wage process (Section 2.3), labor

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[3]Several papers provide theoretical insights into the optimal design of unemployment insurance: Shavell and Weiss (1979), Hopenhayn and Nicolini (1997), Shimer and Werning (2008) and Pavoni (2009) derive the optimal time path of unemployment insurance benefits; Pavoni et al. (2013) consider the optimal time path of insurance and assistance benefits when mandatory work and assisted search are policy instruments; Acemoglu and Shimer (1999) show that the optimal generosity of unemployment insurance depends on workers' willingness to accept employment risk; and Shimer and Werning (2007) propose an approach that is complementary to Baily (1978) and Chetty (2006) and relies on the reservation wage. Michelacci and Ruffo (2015) derive the optimal age-profile of unemployment insurance benefits. Paserman (2008) and Spinnewijn (2015) study the optimal design of unemployment insurance with, respectively, hyperbolic discounting and biased beliefs.

[4]Blau and Gilleskie (2006) and van der Klaauw and Wolpin (2008) analyze, respectively, health insurance and pension reforms with two-earner households. While these papers model couples, they focus on older populations, they do not include employment risk, and they do not compare insurance and assistance programs or explore the importance of the family unit for policy design.

market frictions (Section 2.4), and the intertemporal budget constraint (Section 2.5). Appendix D characterizes optimal behavior.

2.1 Overview

Decisions are made semiannually, i.e., one period lasts for 6 months. Figure 1 illustrates the timing of events. Individuals enter the labor force after completing education. For those in the labor force, each period proceeds as follows: i) marital status is updated; ii) the household observes the woman's fertility outcome (if applicable), and each member's market wage, job destruction status and current-period preference shocks; iii) the household chooses a search intensity for each household member who was non-employed or in education in the previous period; and iv) job offers are realized, and the household makes labor supply and savings decisions.[5]
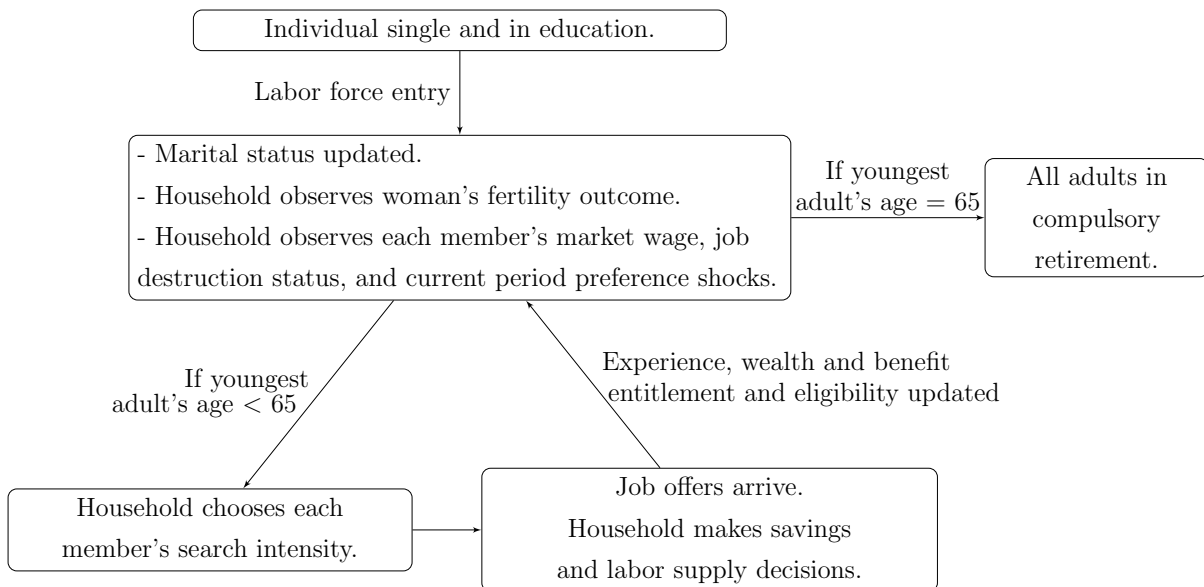

Figure 1: Timing of events over the life cycle.

The labor supply states at the individual level are: non-employment (NE); full-time employment (FT, 40 hours of work per week); retirement (RT); and, for women only, part-time employment (PT, 20 hours of work per week). An individual permanently exits the labor force when he or she enters retirement. Retirement is feasible from age 60 years for women and age 63 years for men, and compulsory at age 65 years for men and women.[6] Once all household members reach the compulsory retirement age there are

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[5]The timing of the transition from education into the labor force is assumed to be exogenous. We do not distinguish between cohabitation and marriage, and individuals cannot marry and divorce in the same period.

[6]The definition of labor supply states is empirically motivated: in the sample, only 5% of men work fewer than 30 hours per week; and employment rates after age 65 are below 5% for men and women.

no further opportunities for search or labor supply decisions; from this point onward, the household supplements any pension and social assistance benefits with the annuity value of the household's wealth.

Marriage is determined by an exogenous process that captures education-based assortative mating. We do not attempt to model the response of marriage to changes in the design of social insurance and assistance programs. This aspect of our approach is consistent with existing empirical evidence showing that welfare programs and in-work benefits have little or no effect on marital status (see, e.g., Eissa and Hoynes, 1998, Ellwood, 2000, and Bitler et al., 2004). For similar reasons, fertility and job destructions are also assumed to be exogenous. Appendix A describes the processes that determine marital status, assortative mating, fertility and job destructions.

Before proceeding, we make the following notational definitions. Women are indexed by i, and men are indexed by j. Age is indexed by t. One unit of t represents 6 months of calendar time, i.e., one model period. In married couples the husband is $\Delta \equiv 5$ periods, i.e., 2.5 years, older than the wife (this reflects the average male-female age difference for newly formed couples in the SOEP estimation sample). Household-level quantities, such as wealth and consumption, are indexed by (i, j, t), with $i = \emptyset$ for a male-headed single household and $j = \emptyset$ for a female-headed single household. In married couples t indexes the age of the wife.

2.2   Preferences

The per-period utility function of woman i at age t is given by

$$U^F(m_{i,j,t}, d_{i,t}, d_{j,t+\Delta}, s_{i,t}, \varepsilon_{i,t}) = u^F(m_{i,j,t}, d_{i,t}, d_{j,t+\Delta}) - \frac{s_{i,t}^2}{2} + \varepsilon_{i,t}(d_{i,t}), \qquad (1)$$

where $m_{i,j,t}$ denotes household consumption and $d_{i,t} \in \mathcal{D}^F \equiv \{FT, PT, NE, RT\}$ denotes the woman's labor supply outcome at age t. If the woman is married, then $d_{j,t+\Delta} \in \mathcal{D}^M \equiv \{FT, NE, RT\}$ denotes the husband's labor supply outcome when the woman is aged t. If the woman is single, then $j = \emptyset$, and $d_{\emptyset,t+\Delta}$ denotes the absence of a husband. $s_{i,t}$ denotes the woman's search intensity at age t. As explained in Section 2.4, an individual who was employed in the previous period will not search, while search intensity is weakly positive for an individual who was non-employed in the previous period. The woman experiences time-varying preference shocks, $\varepsilon_{i,t}(d_{i,t})$, that vary across labor supply states. Preference shocks are assumed to be independent over time, and contemporaneous preference shocks are assumed to be mutually independent and normally distributed with mean zero and standard deviation ς_{FS} for single women and ς_{FC} for married women.

The sub-utility function, u^F, captures the systematic component of the woman's preference for consumption and the leisure times of the household members. Our specification of the sub-utility function is motivated by two established empirical regularities: i) there

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are important nonseparabilities between consumption and leisure (see, e.g., Browning and Meghir, 1991, and Attanasio and Weber, 1995); and ii) there are substantial intra-household cross-spouse correlations in employment and retirement decisions.[7] The former of these regularities largely accounts for the popularity of the single-agent preference specification used by, e.g., French and Jones (2011), which allows nonseparability between consumption and the individual's own leisure time; we extend the same preference specification to allow nonseparability between the spouses' leisure times.

In particular, we specify that

$$u^F(m_{i,j,t}, d_{i,t}, d_{j,t+\Delta}) = \frac{\left(\eta^F(d_{i,t}, d_{j,t+\Delta})m_{i,j,t}/E_{i,j,t}\right)^{1-\rho^F}}{1-\rho^F}, \tag{2}$$

where ρ^F is the coefficient of relative risk aversion for women, and $E_{i,j,t}$ is a household equivalence scale.[8] Consumption therefore is a household public good subject to congestion as household size increases. The woman's taste for consumption, $\eta^F(d_{i,t}, d_{j,t+\Delta})$, depends on the household labor supply outcome and on demographic variables as follows:

$$\log \eta^F(d_{i,t}, d_{j,t+\Delta}) = \sum_{k\in\mathcal{D}^F} \eta^F_{1,k}\mathbf{1}(d_{i,t}=k) + \sum_{k\in\mathcal{D}^F} \eta^F_{2,k}\mathbf{1}(d_{i,t}=k)X^F_{i,t}$$
$$+\eta_3\mathbf{1}(d_{i,t}=NE \cup d_{i,t}=RT) \times \ell(d_{j,t+\Delta}). \tag{3}$$

In the above, $X^F_{i,t}$ is a vector of demographics that may shift consumption and leisure preferences. In our implementation, $X^F_{i,t}$ contains an indicator of the woman being aged 50 or older and indicators of the age category of the household's youngest child (with the reference category being a child aged 6 or above or no children). $\eta^F_{2,k}$ for $k \in \mathcal{D}^F$ measures the impact of these demographic variables on the woman's taste for consumption in each labor supply state. The parameter η_3 captures how the woman's preference for non-work depends on her spouse's leisure time, $\ell(d_{j,t+\Delta})$.[9] We interpret η_3 as the strength of between-spouse leisure complementarities. Finally, the parameters $\eta^F_{1,k}$ for $k \in \mathcal{D}^F$ reflects the consumption and leisure preferences of a single woman aged under 50 without young children.[10]

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[7]Gregg et al. (2010) find polarization of employment across households in several countries including Germany and the US. Relatedly, spouses are frequently observed to retire together (see Blau, 1998, and Coile, 2004). Important motivation for our specification comes from the results of Gustman and Steinmeier (2004), Casanova (2010), and Blundell et al. (2016b) who show that complementarity between spouses' leisure times plays a critical role in explaining couples' employment behavior.

[8]We use the equivalence scale implicit in the German social assistance system. See Appendix B.

[9]The spouse's leisure time is normalized to 1.0 for a non-working spouse, 0.5 for a part-time working spouse, and zero a for full-time working spouse. Spousal leisure time is zero for a single individual.

[10]In the empirical analysis, non-employment and retirement are assumed to be identical in terms of their complementarity with consumption, and retirement and non-employment combined form the reference category.

The utility function and sub-utility function take the same form for men as for women, except that child-related variables are omitted from men's preferences. A married couple's objective function is based on a constant-weighted average of spouses' utilities. We estimate the weight, $\alpha \in [0, 1]$, attached to the woman's utility in the married couple's objective function.

2.3 Wage Process

The market wage of woman i at age t is denoted by $W_{i,t}$. Sample wage observations are mismeasured variant of market wages. We model the wage process jointly with labor supply and thereby account for the effect of wage-based selection into employment on the distribution of accepted wages.

The sampled accepted log real market wage of woman i at age t is given by

$$
\begin{aligned}
\log \widetilde{W}_{i,t} &= \log W_{i,t} + \nu_{i,t}, &(4)\\
&= \beta_1^F + \beta_2^F \mathbf{1}(\text{Education}_i \geq 12 \text{ years}) + \beta_3^F \text{Exp}_{i,t} + \beta_4^F \kappa_{i,t} + \nu_{i,t}. &(5)
\end{aligned}
$$

In the above, Education$_i$ denotes years of education, and Exp$_{i,t}$ denotes years of experience. Experience is zero at the time of entry into the labor force from education, and increases by 0.5 for each period of full-time work and 0.25 for each period of part-time work. $\kappa_{i,t}$ is the unobserved component of the woman's market wage and may be transitory, persistent or permanent. We assume that $\kappa_{i,t}$ is discrete with $\kappa_{i,t} \in \{0, 1\}$. Subsequent to the woman's transition into the labor force from education, $\kappa_{i,t}$ evolves according to

$$
\kappa_{i,t} = \mathbf{1}(\theta_0^F(1 - \kappa_{i,t-1}) + \theta_1^F \kappa_{i,t-1} + \epsilon_{i,t} \geq 0), \tag{6}
$$

where θ_0^F and θ_1^F are parameters that govern the persistence of the wage unobservable and the ϵs are assumed to be serially independent at the individual level with $\epsilon_{i,t} \sim N(0, 1)$.[11] The final term in (5), $\nu_{i,t} \sim N(0, \sigma_{\nu F}^2)$, represents measurement error that affects the

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[11]The unobserved component of the woman's wage at the time of entry into the labor force from education is a draw from the steady state distribution. Solving for the steady state, a proportion Θ^F of women have the high wage unobservable ($\kappa = 1$), where

$$
\Theta^F = \frac{\Phi(\theta_0^F)}{1 + \Phi(\theta_0^F) - \Phi(\theta_1^F)}, \tag{7}
$$

and $\Phi()$ denotes the standard normal cumulative distribution function. For interpretative purposes, it is useful to note that the variance of the wage shocks impacting women's wages is given by

$$
\text{var}(\text{Wage shocks}^F) = (\beta_4^F)^2 \left(\Theta^F(1 - \Phi(\theta_1^F)) + (1 - \Theta^F)\Phi(\theta_0^F)\right). \tag{8}
$$

sampled wage but that is absent from the market wage. Measurement errors are assumed to occur independently over time and over spouses.

The wage process for men is obtained by replacing F with M and i with j in (5), (6) and (7). Thus, all parameters of the wage process may vary by gender. This aspect of the specification captures gender differences in labor market conditions and labor market-related behaviors. For example, a difference in the probability of a positive wage shock by gender may result from gender differences in risk taking, competitiveness or occupational choice, among other mechanisms. In the spirit of, for instance, Attanasio et al. (2008) and Blundell et al. (2016b), contemporaneous market wage shocks may be correlated between spouses in the same household. Specifically, we assume $\text{cov}(\epsilon_{i,t}, \epsilon_{j,t+\Delta}) = \varrho$, while non-contemporaneous wage shocks are assumed to be independent across spouses.[12]

In Section 5.1, we argue that the variance of the wage shocks implied by the estimated model is in line with estimates from the literature. In Section 5.2, we show that the estimated life-cycle model is able to fit the sample values of the intertemporal wage correlation and the between-spouse wage correlation. We also show that the estimated model replicates the observed pattern of wage dynamics.

2.4   Labor Market Frictions

Each period, an employed individual experiences a job destruction with a probability that depends on gender, age, education and marital status.[13] An individual who experiences a job destruction cannot search or work in the current period, while an employed individual who is not subject to a job destruction may remain in employment, if he or she chooses. Job destructions thus constitute a substantial risk for employed individuals.

A non-employed individual may move into employment only if a job offer is received in the current period. The job-offer probability for woman i, who searches with intensity $s_{i,t} \in [0, 1/\chi_{i,t}]$, is given by

$$\Pr(\text{Job offer}) \;=\; \chi_{i,t} s_{i,t}, \tag{9}$$

where search productivity $\chi_{i,t}$ is given by

$$\log(\chi_{i,t}) \;=\; \chi_1^F + \chi_2^F \mathbf{1}(\text{Age}_{i,t} \geq 50) + \chi_3^F \mathbf{1}(\text{Education}_i \geq 12 \text{ years}) + \chi_4^F \text{Married}_{i,t}. \tag{10}$$

The job-offer probability for men is obtained by replacing F with M and i with j in (9) and (10).

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[12]The household is assumed to have no information, beyond that given above, about the values of future market wage shocks. Blundell et al. (2016b) find little evidence of anticipation of wage shocks; for further discussion see Blundell and Preston (1998), Pistaferri (2001, 2003) and Guvenen (2007).

[13]The inclusion of marital status here is empirically motivated: we observe variation in the job destruction rate by marital status, as well as by education, gender and age. Appendix A.4 provides further details.

2.5 Intertemporal Budget Constraint

With no marriage or divorce at time t, the intertemporal budget constraint for household (i, j) is given by

$$A_{i,j,t} = A_{i,j,t-1}(1 + r) + y_{i,j,t} - m_{i,j,t}, \tag{11}$$

where $A_{i,j,t}$ denotes the combined net value of the household's financial, housing and durable assets; r is the real interest rate, assumed to be 3%; and $y_{i,j,t}$ is the net-of-tax value of the household's income from employment and social programs (see Section 2.5.1). Marriage augments household assets by the assets of the incoming spouse. In the event of divorce, the household's assets are assumed to be divided equally between the spouses.[14]

Households are assumed to be unable to borrow against future earnings or future entitlements to benefits from social programs. Reflecting this, household assets must be non-negative:

$$A_{i,j,t} \geq 0. \tag{12}$$

This borrowing constraint amplifies the insurance motive for social assistance and unemployment insurance to smooth the marginal utility of consumption over the life cycle in the presence of shocks, such as wage shocks and job destructions. See Section 6.1 for further discussion.

2.5.1 Household Net Income

Based on the German tax and benefit system, the net-of-tax value of household income for couple (i, j) in period t is given by

$$
\begin{aligned}
y_{i,j,t} &= W_{i,t} h_{i,t} + \text{UI}_{i,t} + \text{Pension}_{i,t} - \text{SSC}_{i,t} \\
&\quad + W_{j,t+\Delta} h_{j,t+\Delta} + \text{UI}_{j,t+\Delta} + \text{Pension}_{j,t+\Delta} - \text{SSC}_{j,t+\Delta} \\
&\quad + \text{SA}_{i,j,t} - \text{Tax}_{i,j,t} + \text{CB}_{i,j,t} - \text{CC}_{i,j,t}.
\end{aligned} \tag{13}
$$

In the above, UI denotes unemployment insurance benefits, SSC denotes social security contributions, and Pension denotes public pension benefits (all three programs are administered at the individual level).[15] SA and Tax denote social assistance benefits and income tax, respectively (both programs are administered at the household level). CB denotes child benefits and CC denotes employment-related child-care costs. h denotes hours of work. The net income for a single household is obtained by taking (13) and suppressing

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[14]This assumption follows the legal default that applies to divorce proceedings, which stipulates equal division of assets accumulated within the marriage.

[15]We do not model disability benefits (which are part of the pension system). In the model, non-employed individuals with work-limiting health conditions receive unemployment insurance and/or social assistance.

the earnings, unemployment insurance, pension, and social security contributions of the person with the opposite gender to that of the household head. Children are assumed to reside in their mother's household.

Unemployment insurance and social assistance are described in Sections 2.5.2 and 2.5.3, respectively. Social security contributions, taxes, pensions, child benefits and child-care costs are described in Appendix C.

2.5.2 Unemployment Insurance

Unemployment insurance benefits provide partial income replacement to eligible and entitled non-employed individuals. We use the following formula for unemployment insurance benefits:

$$\text{UI}_t = \text{Elig}_t \times \mathbf{1}(\text{UIEnt}_t > 0) \times \text{RR} \times \text{NW}_t. \tag{14}$$

The replacement rate, RR, is 0.6 if no children reside in the individual's household or 0.67 if one or more children reside in the individual's household. The net hourly wage, NW_t, is determined by the individual's market wage (see Section 2.3), hours of work in previous employment, and the tax schedule.[16]

An individual's unemployment insurance entitlement period, UIEnt_t, is measured in months and is initialized at the time of entry to non-employment. Reflecting the German system, the initial entitlement period is an increasing function of age: an individual who is under age 45 at the start of his or her non-employment spell has an initial entitlement period of 12 months, while individuals entering non-employment at ages 45–46, 47–56 and greater than or equal to 57 have initial entitlement periods of 18, 24 and 30 months, respectively. The entitlement period evolves through the non-employment spell as follows:

$$\text{UIEnt}_t = \max\{\text{UIEnt}_{t-1} - 6, 0\}. \tag{15}$$

An individual's unemployment insurance eligibility, $\text{Elig}_t \in \{0, 1\}$, is determined at the time of entry to non-employment and is fixed over the non-employment spell. Specifically, an individual entering non-employment is eligible ($\text{Elig}_t = 1$) for unemployment insurance benefits if he or she was continuously employed in the past year or entered employment in the past year with remaining unemployment insurance entitlement, and otherwise the

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[16]Additionally, unemployment insurance benefits are capped at 1,750 euros per month.

individual is ineligible ($\text{Elig}_t = 0$).[17]

Unemployment insurance benefits are paid without regard to the spouse's earnings, and benefits are not linked to the household's interest income; therefore, unemployment insurance benefits may be received by non-employed individuals residing in households with substantial earned or unearned income. Furthermore, since there is no wealth test, non-employed individuals receive unemployment insurance benefits irrespective of their ability to smooth the marginal utility of consumption by dis-saving.

2.5.3 Social Assistance

Social assistance is a household-level benefit that provides a permanent income floor to wealth-poor households. Based on the German legislation, we use the following formula for social assistance benefits:

$$
\begin{aligned}
\text{SA}_{i,j,t} =\ & \mathbf{1}(A_{i,j,t} < 10,000 \text{ euros}) \\
& \times \max\{\text{SAFloor} - \text{UI}_{i,t} - \text{UI}_{j,t+\Delta} - W_{i,t}h_{i,t} - W_{j,t+\Delta}h_{j,t+\Delta} \\
& \quad - \text{Pension}_{i,t} - \text{Pension}_{j,t+\Delta} - \text{CB}_{i,j,t}, 0\}.
\end{aligned} \tag{16}
$$

In the above, SAFloor is the social assistance income floor, which includes housing benefits. The social assistance income floor is 600 euros per month for a single household without children and increases with the number of adults and children in the household, e.g., the social assistance income floor for a married couple with two pre-school aged children is 1,638 euros per month. Appendix B provides a complete description of the social assistance income floor.

In contrast to unemployment insurance, social assistance is only paid to households with assets below 10,000 euros, and is withdrawn at a rate of 100% against the household's income from earnings, unemployment insurance, pensions and child benefits.[18] Social assistance is therefore focused on households that would otherwise have low consumption.

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[17]According to the German legislation, individuals who quit their jobs and voluntarily transitioned into non-employment must wait three months before starting to receive unemployment insurance benefits. We neglect this rule because eligible individuals are seldom prevented from claiming unemployment insurance immediately upon entering non-employment. Specifically, our calculations based on administrative data collected by the German Federal Employment Agency for the year 2000 show that less than 5% of eligible new entrants to unemployment were sanctioned for quitting previous employment (Bundesagentur für Arbeit, 2013).

[18]We ignore the lower withdrawal rate against earnings that applies to households with very low earnings. This is without consequence because modeled employment entails at least 20 hours of work per week, thus ensuring that earnings are too high to qualify for the lower withdrawal rate.

3 Data and Sample

Estimation of the model uses a semiannual panel sample of west German singles and married couples constructed from the German Socio-Economic Panel (SOEP) survey data sets (see Wagner et al., 2007, for a description of the SOEP). The sample covers the years 1991–2005. Although the SOEP surveys are conducted annually, they provide sufficient information to construct semiannual measures of labor supply, household type (single or married) and children. Attention is restricted to single households in which the household head is aged 16–65 years as well as married couples in which both spouses are aged 16 years or older and at least one spouse is aged 65 years or younger. We exclude individuals before their initial transition into the labor force from education. We also exclude households in which any adult household member reports being self-employed or employed by the Civil Service. The estimation sample contains 222,750 individual-half-year observations. Table 1 reports descriptive statistics.

Variable	Single men		Single women		Married men		Married women	
	Obs.	Mean	Obs.	Mean	Obs.	Mean	Obs.	Mean
Age (years)	13,959	39.32	20,541	42.40	89,125	46.12	89,125	43.24
Education (years)	13,959	12.29	20,541	11.76	89,125	11.76	89,125	11.27
High education	13,959	0.63	20,541	0.58	89,125	0.55	89,125	0.51
Experience (years)	13,959	14.97	20,541	14.27	89,125	22.95	89,125	12.15
Full-time employed (FT)	13,959	0.73	20,541	0.47	89,125	0.73	89,125	0.26
Part-time employed (PT)	-	-	20,541	0.14	-	-	89,125	0.27
Retired (RT)	13,959	0.05	20,541	0.10	89,125	0.11	89,125	0.07
Non-employed (NE)	13,959	0.28	20,541	0.30	89,125	0.16	89,125	0.40
Assets (euros, household)	533	49,174	805	44,766	3,580	150,563	3,580	150,563
Wage (euros, hourly)	3,358	15.56	4,535	12.71	23,669	16.99	16,726	11.59
Age 1st child (years)	-	-	5,394	11.37	44,424	10.04	44,424	10.04

Note: High education is defined as 12 or more years of education. Assets (comprising financial, housing and durable assets) are calculated using information collected from a household questionnaire that was administered as part of the 2002 SOEP survey. We right censor assets at 250,000 euros for single-adult households and 500,000 euros for married households. The hourly wage is defined as gross earnings, including overtime pay, in the month prior to the survey date divided by contractual working hours, including hours of paid overtime, during the same period. Wages are therefore observed only for individuals who were employed in the month prior to the survey date. Nominal variables are expressed in year 2000 prices using the Retail Price Index.

Table 1: Descriptive statistics for the SOEP estimation sample 1991–2005.

4   Indirect Inference Estimation

We use indirect inference to estimate the parameters of the life-cycle model (see Gourier-oux et al., 1993, Smith, Jr, 1993, and Gallant and Tauchen, 1996). This simulation-based estimation method uses an auxiliary model to summarize both the estimation sample and a sample simulated using the decision rules and other equations of motion given by the life-cycle model. Values of the parameters of the life-cycle model are then chosen to maximize the similarity between the estimation sample and the simulated sample, as viewed from the perspective of the auxiliary model.

Following, e.g., Adda et al. (2017) and Low and Pistaferri (2015), we use an indirect inference estimation routine based on matching the estimates of the auxiliary model parameters obtained from the estimation sample with the corresponding estimates obtained from the simulated sample.[19] Our indirect inference estimator is given by

$$\widehat{\omega} = \operatorname*{argmin}_{\omega} \left(\widehat{\psi} - \widehat{\psi}(\omega) \right)' \Sigma \left(\widehat{\psi} - \widehat{\psi}(\omega) \right), \tag{17}$$

where $\widehat{\psi}$ denotes the vector of auxiliary model parameter estimates obtained from the estimation sample, and $\widehat{\psi}(\omega)$ denotes the auxiliary model parameters estimated using a sample simulated from the life-cycle model with parameter values ω. The diagonal weighting matrix Σ has diagonal elements equal to the inverse of the variance of each of the auxiliary model parameters, estimated using bootstrapping with household-level clustering. We obtain standard errors using the formula provided by Gourieroux et al. (1993).

We estimate the 44 parameters of the life-cycle model by matching 109 auxiliary model parameters. Each auxiliary model parameter summarizes a feature of wages, labor supply or wealth. Here we summarize the auxiliary model parameters and link these parameters to the identification of the parameters of the life-cycle model. Tables 8 and 9 in Appendix E give a complete description of the auxiliary model and provide further details about identification.

One group of auxiliary model parameters summarize average wages by gender, experience and education. These auxiliary model parameters provide identifying information on the intercept and the coefficients on education and experience in the gender-specific wage processes. To separate selection effects from wage determinants, we also match parameters that summarize average wages by household characteristics that affect labor supply but do not enter the wage process. Further auxiliary model parameters summarize

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[19]In related life-cycle models, Altonji et al. (2013) conduct indirect inference based on the quasi likelihood of the auxiliary model, and Gourieroux et al. (1993) and van der Klaauw and Wolpin (2008) base estimation on the score function of the auxiliary model. De Nardi et al. (2010) and Eckstein and Lifshitz (2011) use the closely related Method of Simulated Moments.

cross-sectional wage heterogeneity, wage dynamics and cross-spouse wage dependencies. These auxiliary model parameters are informative about the wage shock parameters.

Another group of auxiliary model parameters summarize individual labor supply outcomes and employment dynamics by gender, marital status, education and experience. Intuitively, the auxiliary model parameters that summarize the rates of voluntary transitions out of employment are informative about preference parameters. Given information about preferences, auxiliary model parameters pertaining to labor supply outcomes themselves are informative about the productivity of job search. Additional auxiliary model parameters describe the joint distribution of husbands' and wives' labor supply outcomes. These parameters are informative about the strength of between-spouse leisure complementarity and the weight on the woman's utility in the couples objective function. A final group of auxiliary model parameters describe wealth by marital status, gender, age and education. These auxiliary model parameters are informative about risk preferences.

5   Estimation Results

In this section, we present our estimates of the parameters of the life-cycle model, demonstrate the model's good in-sample fit, and show that implications of the model are consistent with previous studies.

5.1   Parameter Estimates

Estimates of the parameters of the life-cycle model are reported in Tables 2, 3, and 4. Table 2 shows that the market wage increases with education and experience. Of particular relevance to the subsequent analysis, having at least 12 years of education increases the market wage by 19% for women and by 30% for men. The unobserved component of the market wage is persistent, with wage shocks being large but infrequent. We use (8) to calculate that the wage shocks have a standard deviation of 0.108 log points for women and 0.141 log points for men; these figures are in line with the results for Germany reported by Krueger et al. (2010, estimates of the variance of permanent log wage shocks in Tables 7A and 7B) and Fuchs-Schündeln et al. (2010, variance of log wages in Figure 6). Averaging over the unobserved component of the market wage and conditioning on education and experience, we find that the market wage is 12% higher for men than for women; the estimated model is able to fit the observed gap of 0.33 log points between men's and women's unconditional accepted wages (see Table 13) through a combination of selection into employment and higher returns to education and experience for men. We also find that the wage unobservables are positively correlated between spouses; ancillary calculations show that the estimated correlation of 0.609 between the underlying errors in (6) that determine the evolution of spouses' wage unobservables translates into a

steady state correlation of 0.200 between the spouses' contemporaneous unobserved wage components, $\kappa_{i,t}$ and $\kappa_{j,t+\Delta}$.

	Women	Men
Intercept (β_1^F, β_1^M)	2.343 (0.006)	2.818 (0.008)
Exp/40 (β_2^F, β_2^M)	0.056 (0.012)	0.160 (0.018)
Education$\geq$ 12 years (β_3^F, β_3^M)	0.193 (0.014)	0.301 (0.017)
$\mathrm{P}(\kappa_t = 1 \,|\, \kappa_{t-1} = 1)$ $(\Phi(\theta_1^F), \Phi(\theta_1^M))$	0.990 (0.001)	0.954 (0.005)
$\mathrm{P}(\kappa_t = 1 \,|\, \kappa_{t-1} = 0)$ $(\Phi(\theta_0^F), \Phi(\theta_0^M))$	0.028 (0.004)	0.034 (0.004)
Loading on persistent unobservable (β_4^F, β_4^M)	0.893 (0.019)	0.713 (0.012)
Between-spouse correlation of persistent wage shocks (ϱ)	0.609 (0.053)	
Standard deviation of measurement error $(\sigma_{\nu F}, \sigma_{\nu M})$	0.014 (0.002)	0.019 (0.004)

Note: Standard errors in parentheses. $\Phi()$ is the standard normal distribution function.
Table 2: Wage equation.

Table 3 reports negative intercepts in the equations describing women's and men's preferences for full-time work and women's preference for part-time work. Recall, non-employment and retirement combined form the reference category (see footnote 10). Therefore, aside from any leisure complementarities, women and men have positive utility of leisure time. In terms of magnitudes, the disutility of working full-time is around 45% of consumption for women without children and under the age of 50, and it is 10% of consumption for men under the age of 50. The disutility of working part-time amounts to 34% of consumption for women without children and under the age of 50. The distaste for full-time work increases with age for men and women, and women whose youngest child is under 3 years of age have an additional distaste for full-time work.[20]

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[20]The positive preference increments arising from the presence of young children derive from the relative flatness of the budget constraint for many women. This flatness of the budget constraint reflects the combined effects of the withdrawal of social assistance benefits against other sources of household income, child-care costs and the low market wages of women.

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	Women	Men
State-specific taste for consumption:		
Full-time employment: Intercept	−0.607 (0.014)	−0.105 (0.051)
$(\eta^F_{1,FT}, \eta^M_{1,FT}\ \eta^F_{2,FT}, \eta^M_{2,FT})$ Youngest child aged < 3	−0.408 (0.021)	-
$3 \leq$ Youngest child aged < 6	0.251 (0.082)	-
Age ≥ 50	−0.326 (0.038)	−0.352 (0.013)
Age $\geq 50 \times$ Married	0.106 (0.055)	−1.443 (0.033)
Part-time employment: Intercept	−0.415 (0.021)	-
$(\eta^F_{1,PT}, \eta^F_{2,PT})$ Youngest child aged <3	0.169 (0.025)	-
$3 \leq$ Youngest child aged < 6	0.734 (0.095)	-
Age ≥ 50	−0.250 (0.045)	-
Age $\geq 50 \times$ Married	0.301 (0.058)	-
Further preference parameters:		
CRRA (ρ^F, ρ^M)	2.146 (0.116)	2.343 (0.045)
Scale of preference shocks for single individuals $(\varsigma_{FS}, \varsigma_{MS})$	0.553 (0.029)	0.753 (0.032)
Scale of preference shocks for married individuals $(\varsigma_{FC}, \varsigma_{MC})$	0.765 (0.020)	1.320 (0.084)
Between-spouse leisure complementarity (η_3)	0.064 (0.027)	
Weight on female spouse (α)	0.731 (0.014)	

Note: Standard errors in parentheses.

Table 3: Preference parameters.

Also from Table 3, the CRRA is estimated to be 2.146 for women and 2.343 for men. These figures are in line with previous studies, which typically report estimates of the CRRA in the range of 1–3 (see, e.g., Attanasio and Weber, 1995). In married couples, women receive a weight of 0.731 (a structural interpretation of this parameter is unavailable because the parameter value partly reflects the scaling of women's and men's

utility functions). Our estimate of the leisure complementarity parameter implies that a non-working spouse increases the utility of consumption when not working by 6.6%. Table 4 shows that search productivity decreases with age, increases with education, and is lower for married individuals than for singles.

	Women	Men
Intercept (χ_1^F, χ_1^M)	−0.930 (0.048)	−0.971 (0.036)
Age ≥ 50 (χ_2^F, χ_2^M)	−2.506 (0.394)	−2.593 (0.136)
Education ≥ 12 years (χ_3^F, χ_3^M)	0.263 (0.062)	0.235 (0.048)
Married (χ_4^F, χ_4^M)	−0.685 (0.037)	−0.593 (0.082)

Note: Standard errors in parentheses. See (10) for the relationship between these parameters and search productivity.

Table 4: Search productivity parameters.

5.2 In-Sample Goodness of Fit

We assess in-sample fit by examining the model's ability to match the 109 auxiliary model parameters, which summarize the patterns of labor supply, wages and wealth seen in the estimation sample. Tables 10-13 in Appendix F show that the estimated model obtains a close fit to the auxiliary model parameter estimates obtained from the estimation sample. Regarding labor supply, we are successful at fitting the observed frequencies of employment for prime-age men and women and we are able to fit the marked decline in employment rates after 50 years of age that is observed for both genders. The model is also able to explain the observed pattern of voluntary quits by age, gender and education. We note that the search productivity parameters reported in Table 4 translate into a low re-employment rate for older individuals; the combination of the low re-employment rate for older individuals, the voluntary quit rate and the job destruction rate explains the observed decline in employment at older ages. The estimated model also replicates closely the joint distribution of the labor supply outcomes of wives and husbands, e.g., in the estimation sample we observe the wife working full-time and the husband being non-employed in 4% of married couples while the model implies a figure of 3%, and the estimation sample and the model concur on the wife being non-employed and the husband working full-time in 33% of married couples.

Furthermore, the model does a good job at fitting wealth and wages; for instance, average wealth for married couples where the husband is over the age of 50 is 197,000 euros in the estimation sample and 192,000 euros in the simulated sample, and the correlations

between log wages in consecutive years for women and men are 0.11 and 0.12, respectively, in the estimation sample, compared to 0.13 and 0.12 in the simulated sample.

5.3   Consistency with Previous Studies

Following, e.g., Todd and Wolpin (2006) and Low and Pistaferri (2015), we assess the validity of the estimated model by comparing the model's implications with findings from related studies. In particular, we show that the estimated model implies that employment depends on key parameters of the unemployment insurance system in a way that is consistent with findings from reduced-form studies that exploit plausibly exogenous variation in benefit rules. These quantities are not targeted in our estimation routine, and this exercise therefore provides external support for the estimated model. Summarizing briefly, prior work suggests that a one-week increase in the unemployment insurance entitlement period increases the time until re-employment by 0.05–0.15 weeks.[21] Regarding the level of benefits, reduced-form evidence is less plentiful and more mixed. Prior research suggests that a 10 percentage point increase in the replacement rate increases the time until re-employment by 0.5–1.5 weeks, and reports elasticities ranging from 0.15 to above 2 (Card et al., forthcoming, survey recent findings).[22]

Based on the estimated model, we derive marginal effects mirroring those reported in the reduced-form literature. Specifically, using the unemployment insurance system

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[21]For example, looking at Germany and using a sample period similar to our study, Schmieder et al. (2012, Table II) exploit age-based discontinuities and find that a one-week extension of the initial entitlement period increases the time until re-employment by 0.1–0.13 weeks for individuals in their 40s. Using a difference-in-differences approach to estimate the same quantity for Austria, Lalive et al. (2006, Table 5) report values of 0.05 weeks at age 40–49 and 0.1 weeks at age 50 and above. Also see the surveys by Atkinson and Micklewright (1991) and Tatsiramos and van Ours (2014).

[22]Using a difference-in-differences approach and data from Austria, Lalive et al. (2006, Table 5) report that a 6 percentage point increase in the replacement rate increases the average duration of non-employment 0.38 weeks. Using a regression kink design, Landais (2015) finds elasticities for the duration of benefit claims with respect to the replacement rate of between 0.2–0.7 for the US. Card et al. (forthcoming) report elasticities for the time until re-employment with respect to the replacement rate for Austria ranging from 1.4 to above 2. There is little evidence on replacement rate effects for Germany. One exception is Hunt (1995), who finds that a cut of the replacement rate in the 1980s for individuals without children increased the exit rate from unemployment into retirement. Early studies estimated the employment effects of the level and duration of unemployment insurance benefits without appeal to exogenous policy changes, discontinuities, or other quasi-natural sources of variation. Using US data, Katz and Meyer (1990) find that a one-week extension of the initial entitlement period increased the time until re-employment by 0.16–0.20 weeks. Concerning the same quantity, Moffitt and Nicholson (1982) report a figure of 0.1 weeks for the US, and Ham and Rea (1987) find effects in the range of 0.26–0.33 weeks for Canada. Katz and Meyer (1990) report that a 10 percentage point increase in the replacement rate increases the duration until re-employment by 1.2–1.5 weeks.

	Age at start of non-employment spell (years)		
	20	30	40

Panel A: Effect of one-week increase in the initial entitlement period on average weeks until re-employment:

	20	30	40
Women	0.095	0.126	0.121
Men	0.091	0.126	0.139

Panel B: Effect of 10 percentage point increase in the replacement rate on average weeks until re-employment:

|	20	30	40
Women	1.256	0.737	0.549
Men	1.154	0.933	0.982

Note: Results are based on 135,195 simulated non-employment spells. Spells are right-censored at 30 months. Only eligible individuals are included. To ensure comparability with the literature, which generally reports effects for the gross replacement rate, our net replacement rate effects have been scaled by $(1-\tau)^{-1}$, where τ is the average payroll deduction rate of 0.37.

Table 5: Effect of unemployment insurance on the duration until re-employment.

described above in Section 2.5.2, we simulate inflow samples of unemployment insurance-eligible individuals entering non-employment at ages 20, 30, and 40 years. Subsequent employment outcomes are simulated under a baseline regime and under two counterfactuals. In the baseline regime, the unemployment insurance system is unchanged: the initial entitlement period is 12 months for individuals entering non-employment before age 45, and the replacement rate is 60% for individuals without children (or 67% for those with children). In the first counterfactual, there is an unanticipated increase of 6 months in the initial entitlement period. In the second counterfactual, there is an unanticipated increase in the replacement rate of 10 percentage points, occurring at the start of the non-employment spell. Panel A in Table 5 summarizes the implications of the estimated model with respect to the initial entitlement period.[23] The model predicts that a one-week increase in the initial entitlement period increases the duration until re-employment

[23]Similar to Schmieder et al. (2012), we rescale the employment effect of a 6 month increase in the initial entitlement period to obtain the effect of a one-week benefit extension.

by 0.09–0.14 weeks. Consistent with Schmieder et al. (2012), the employment effects of benefit extensions vary little by gender or age. Panel B in Table 5 shows that a 10 percentage point increase in the replacement rate is predicted to increase the duration until re-employment by 0.5–1.6 weeks, with effects at ages 30 and 40 years being slightly larger for men than for women.
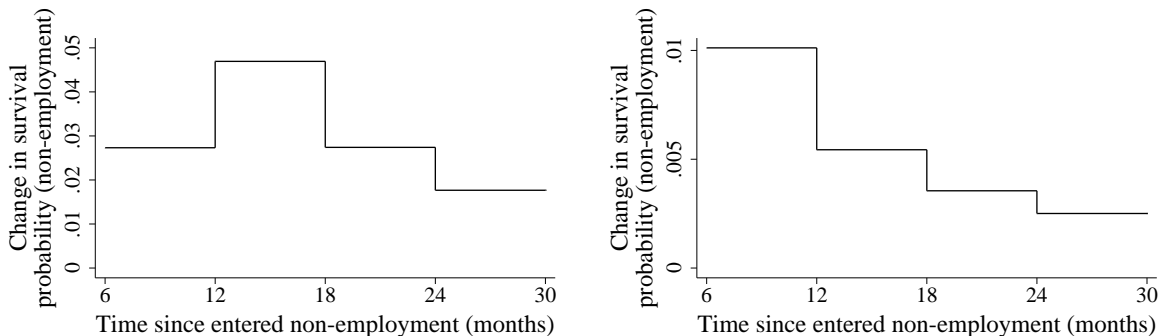
(a) Initial entitlement period extended from 12 to 18 months.

(b) Replacement rate increased by 10 percentage points.

Note: Survivor functions are estimated using a pooled inflow sample of unemployment insurance-eligible individuals entering non-employment at ages 20, 30 and 40 years.

Figure 2: Effect of unemployment insurance on the non-employment survivor function.

As a further plausibility check, we show that the model-implied effect of unemployment insurance on the timing of exits from non-employment is in line with previously documented patterns.[24] Consistent with the empirical results of Lalive et al. (2006), Figure 2 shows that the effect of an increase in the initial entitlement period from 12 to 18 months is concentrated around the time of benefit exhaustion. In contrast, and again consistent with Lalive et al. (2006), the model implies that the employment effect of a 10 percentage point increase in the replacement rate occurs mainly during the period of unemployment insurance covered non-employment, i.e., during the first 12 months of the non-employment spell.

6   Optimal Social Assistance and Unemployment Insurance

We use the estimated life-cycle model to provide empirical evidence about the optimal mix and optimal generosity of social assistance and unemployment insurance. We also

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[24]Given the semiannual decision-making frequency in the model, exits from non-employment are possible only at 6 month intervals.

explore how the population share of married households affects the optimal design of social assistance and unemployment insurance.

6.1 Trading off Insurance, Incentives and Redistribution

We start with a conceptual discussion of the insurance, incentive (moral hazard) and redistributive effects of social assistance and unemployment insurance. We first abstract from redistribution by considering the effects of social assistance and unemployment insurance for a society of single women or single men who share the same level of education. In this case, optimal benefit generosities are determined by trading off the provision of insurance against the moral hazard effects on saving, search and voluntary quits (since individuals who quit their jobs may receive social assistance and unemployment insurance, both benefit programs distort incentives by encouraging voluntary transitions into non-employment, see Sections 2.5.2 and 2.5.3 for further discussion). Social assistance and unemployment insurance have different insurance and incentive effects, which reflect differences in how the programs are targeted. The optimal combination of these programs, therefore, may involve both social assistance and unemployment insurance.[25]

In more detail, unemployment insurance provides temporary earnings-related assistance to individuals who recently left employment. Unemployment insurance therefore mitigates the short-term effects of job loss, irrespective of an individual's position in the earnings distribution. In contrast, social assistance guarantees a permanent universal minimum household income and thus is effective at mitigating both the short-term and long-term effects of job loss for low-wage individuals.

Both unemployment insurance and social assistance discourage saving and search and encourage voluntary quits. However, there are two key differences between the incentive effects of social assistance and unemployment insurance. First, because unemployment insurance is earnings-related while the social assistance income floor is universal, the moral hazard effects of unemployment insurance operate throughout the wage distribution while the adverse incentive effects of social assistance are limited to low-wage individuals. Second, because unemployment insurance benefits are time-limited, the disincentive effect of unemployment insurance is limited to the initial phase of a spell of non-work while social assistance has a longer term disincentive effect on search.

In the presence of heterogeneity in education there is a redistributive motive for social programs that arises because education increases wages and reduces job destructions. Both social assistance and unemployment insurance are redistributive; however, by tar-

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[25]For discussion of the optimal unemployment insurance replacement rate when ex ante identical individuals can save and borrow, either via perfect capital markets or with some restrictions, see Flemming (1978), Acemoglu and Shimer (1999), Chetty (2008), and Lentz (2009). In contrast to our analysis, these papers consider unemployment insurance in the absence of social assistance or family labor supply.

geting directly low-income individuals, social assistance redistributes strongly toward low-educated individuals. Due to its link with earnings and the time-limited nature of the benefits, unemployment insurance is less redistributive than social assistance.

6.2 Welfare Metric

We evaluate the welfare implications of policy reforms using a weighted average of money-metric measures of women's and men's lifetime gains. Formally, the welfare value of a move from the baseline environment, specifically the year 2000 social assistance and unemployment insurance system, to an alternative policy environment, A, is defined as

$$W_A = \Upsilon \gamma_A^F P_0^F + (1 - \Upsilon) \gamma_A^M P_0^M, \tag{18}$$

where γ_A^F and γ_A^M denote the per-period money-metric values to women and men of a move to environment A (further details are provided below), P_0^F and P_0^M denote the average discounted duration until death for women and men, measured at entry into the labor force from education, and Υ may be interpreted as either the share of women in the population or the social planner's weight on women's welfare gains. Given approximately equal shares of women and men in the population under study, we focus on the results for $\Upsilon = 0.5$ and interpret the resulting welfare value as the average per-person value of a move from the baseline system to the alternative policy environment.

The key inputs to the welfare value are the per-period money metric values of the policy change, γ_A^F for women and γ_A^M for men. Similar to the equivalent variation-based measure used in Low et al. (2010), γ_A^F and γ_A^M correspond to the per-period adjustments in baseline consumption required to equalize women's and men's expected discounted lifetime utilities across the baseline and alternative environments. Formally, γ_A^F and γ_A^M solve:

$$\mathbb{E}\left[\sum_{\tau=\underline{t}_i}^{\overline{T}^F} \delta^{(\tau-\underline{t}_i)} U^F \left(m_{i,j,\tau}^A, d_{i,\tau}^A, d_{j,\tau+\Delta}^A, s_{i,\tau}^A, \varepsilon_{i,\tau} \right) \middle| \text{Env. } A \right] =$$

$$\mathbb{E}\left[\sum_{\tau=\underline{t}_i}^{\overline{T}^F} \delta^{(\tau-\underline{t}_i)} U^F \left(m_{i,j,\tau}^B + \gamma_A^F + \gamma_A^M \text{Married}_{i,\tau}, d_{i,\tau}^B, d_{j,\tau+\Delta}^B, s_{i,\tau}^B, \varepsilon_{i,\tau} \right) \middle| \text{Env. } B \right], \tag{19}$$

along with the corresponding equality for men. Here, $\underline{t}_i$ denotes the period of woman i's entry into the labor force from education, Env. B refers to the baseline environment and Env. A refers to the alternative environment. Note that because consumption is a public good within the household, the married woman's utility is impacted by the consumption increment for men, and vice versa. The expectations in (19) and in the corresponding condition for men are taken with respect to education and with respect to all shocks, including wage shocks and job destructions. The consumption increments γ_A^F and γ_A^M therefore capture preferences for insurance and redistribution.

6.3 Social Assistance

Our policy analysis starts by exploring the behavioral effects and the optimal generosity of social assistance in the presence of the existing unemployment insurance system. In particular, we consider proportional adjustments of the social assistance income floor while holding fixed the unemployment insurance replacement rate at its baseline level of 60%. To facilitate comparisons of different generosities of social assistance, we vary the social assistance income floor while imposing a flat-rate tax on household net income that ensures that the economy's net budget position is the same as under the baseline generosity of social assistance, i.e., we consider reforms to social assistance that are revenue equivalent to the baseline system.[26]

Our results reveal considerable substitution between social insurance from social assistance and intra-household insurance from savings and labor supply. In particular, Figures 3(a) and 3(b) show that moving from the baseline social assistance system to a less generous system increases the employment rates of single and married women and men, reflecting an increase in search incentives and a decrease in incentives to voluntarily quit employment. We note that the employment rate of married women does not depend strongly on the generosity of social assistance because the withdrawal of social assistance benefits against the husband's earnings leaves most married women without support from social assistance irrespective of their own behavior. Figure 3(c) shows that wealth accumulation increases as the social assistance income floor is decreased below the baseline level. While the increase in wealth accumulation appears large, it is important to note that the increase in wealth accumulation includes both an increase in precautionary savings in response to the decrease in insurance from social assistance, and an increase in life-cycle saving, driven by the marked increase in employment.

Figure 3(d) shows that the optimal social assistance income floor is 59% of the baseline level. The result implies that, e.g., a married couple with two pre-school aged children optimally receives a maximum of 966 euros per month in social assistance benefits, instead of the baseline maximum of 1,638 euros per month. While the optimal generosity of social assistance is substantially less than the existing level in Germany, it is still moderately generous by international standards. The lifetime welfare gains from a move from the baseline system to the optimal social assistance system average 13,636 euros per person
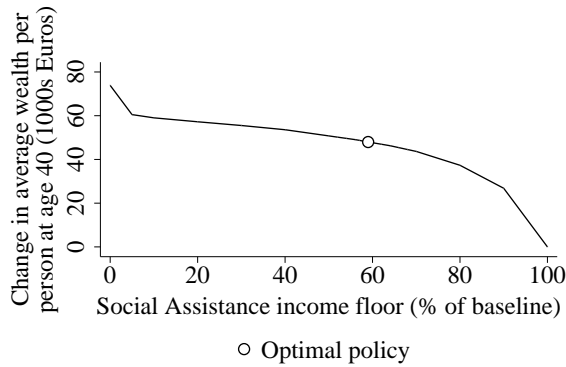
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[26]For each policy environment, we ensure revenue equivalence to the baseline system by imposing a flat-rate tax or subsidy on net household income from earnings, interest on wealth, child benefits and unemployment insurance benefits. Revenue equivalence refers to the same aggregate value of taxes plus Social Security contributions, less social assistance, unemployment insurance, and child and public pension benefits. Imposing revenue equivalence in this way ensures that the unemployment insurance replacement rate continues to be the fraction of net earnings replaced by unemployment insurance benefits. In all optimality exercises, we apply the same replacement rate to individuals with and without dependent children.
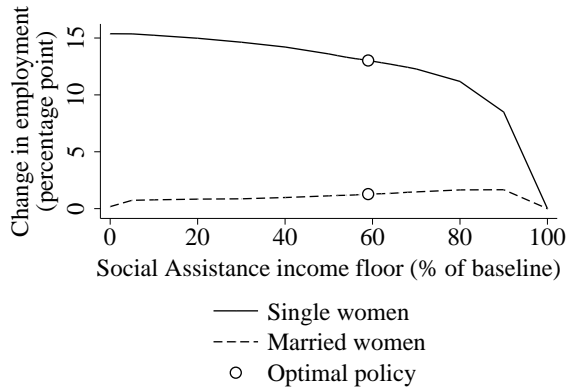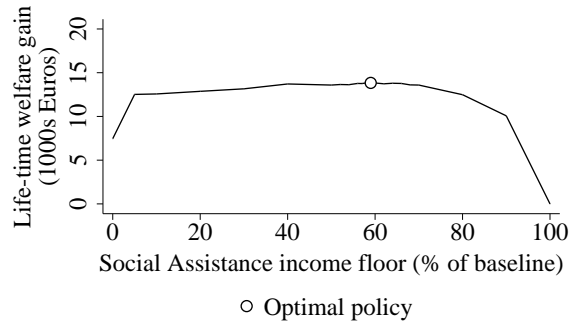
(a) Female employment.
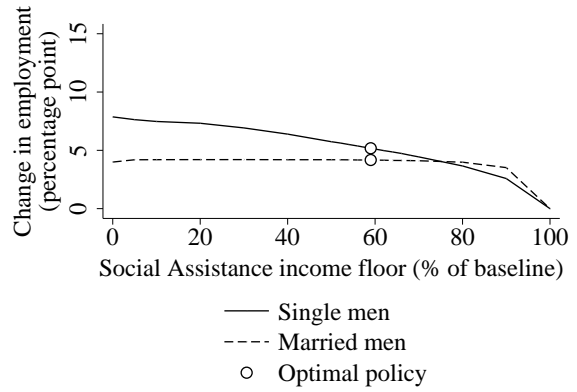
(b) Male employment.

(c) Wealth.

(d) Welfare.

Note: An additional flat-rate tax or subsidy on net household income from earnings, interest on wealth, child benefits and unemployment insurance benefits ensures that all policy environments are revenue equivalent to the baseline system. Income floors above 100% of the baseline generosity (in conjunction with an unemployment insurance replacement rate of 60%) are prohibitively expensive, i.e., there is no additional flat-rate tax on net income from earnings, interest on wealth, child benefits and unemployment insurance benefits that imposes revenue equivalence to the baseline environment.

Figure 3: Wealth, labor supply and welfare by social assistance generosity.

(or 27,272 euros per couple), and represent an increase of 2.91% in the present value of average lifetime consumption. Increasing the weight on low-income individuals in the social welfare function is likely to increase the optimal generosity of social assistance. Section 6.6 speaks to this question by calculating optimal policies for different educational groups.

6.4 Unemployment Insurance

Mirroring our analysis in Section 6.3, we now explore the behavioral effects and the optimal generosity of unemployment insurance in the presence of the existing social assistance

system. We continue to consider revenue-equivalent reforms (see footnote 26). By considering the optimal generosity of unemployment insurance in the presence of permanent universal social assistance, we differ from, e.g., Hopenhayn and Nicolini (1997), Saez (2002), Chetty (2006) and Shimer and Werning (2008). This distinction is important because neglecting the insurance provided by social assistance will over-state the insurance value of unemployment insurance.[27]

Similar to our results on social assistance, we find substitution between the social insurance provided by unemployment insurance and intra-household insurance from savings and labor supply. Figures 4(a) and 4(b) show that the employment rates of single and married women and men decrease with the replacement rate. In contrast to the findings for social assistance, the employment rate of married women increases markedly in response to cuts in the replacement rate, reflecting that unemployment insurance benefits are not contingent on the spouse's earnings. Figure 4(c) shows that wealth accumulation decreases with the generosity of unemployment insurance. However, conditional on the welfare gain, wealth accumulation is less sensitive to unemployment insurance than to social assistance, which reflects that social assistance is focused on households that have no other means of funding current consumption.

Figure 4(d) shows that an unemployment insurance replacement rate of 0% maximizes the average per-person welfare gain. The lifetime welfare gains from this reform average 11,624 euros per person (or 23,248 euros per couple), and represent an increase of 2.53% in the average present value of lifetime consumption. Three factors are of particular importance in driving the optimal replacement rate to 0%. First, we consider the optimal design of unemployment insurance in the presence of generous social assistance. Note that unemployment insurance increases household income only when the value of unemployment insurance exceeds the value of social assistance. In the presence of generous social assistance, this happens only when the individual had high previous earnings or the household is ineligible for social assistance because it has other income (e.g., a spouse's earnings) or substantial wealth. Thus, given generous social assistance, unemployment insurance does not provide insurance to the poorest households but it stills distorts incentives for richer households. In Section 6.5 we show that a non-zero replacement rate is optimal in the presence of less generous social assistance. Second, Figures 4(a)–4(b) show that the moral hazard effect of unemployment insurance on employment continues to operate at low levels of benefit generosity, and this implies that even low levels of unemployment insurance are distortionary. Third, reflecting the administration of unemployment insurance in Germany (see footnote 17), benefits are available to individuals who voluntarily

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[27]We note that some of the previous literature on optimal unemployment insurance has abstracted from wage heterogeneity and time limits on benefit receipt (see, e.g., Baily, 1978, and Chetty, 2006, and subsequent applications). Without wage heterogeneity and time limits, there is no distinction between unemployment insurance and social assistance.
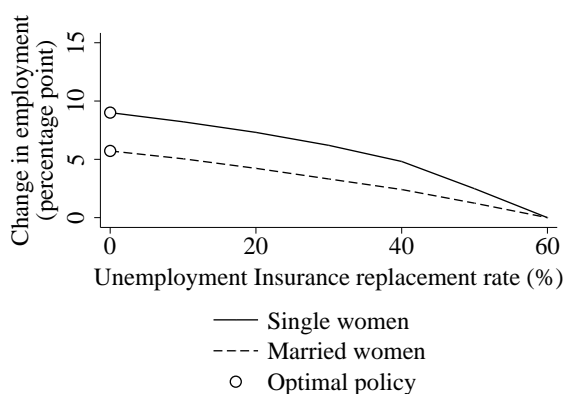
(a) Female employment.
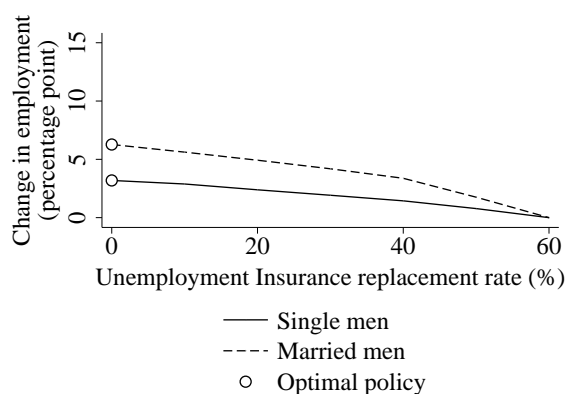
(b) Male employment.
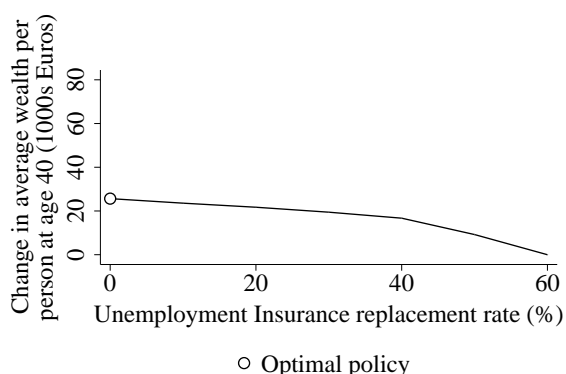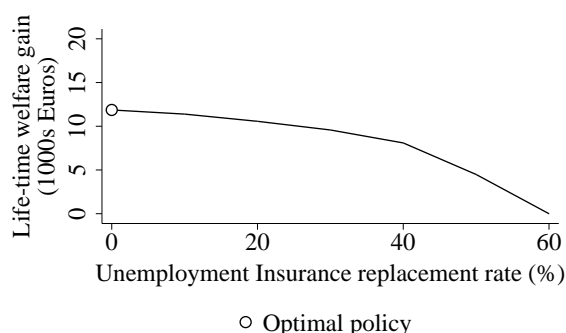
(c) Wealth.

(d) Welfare.

Note: See note to Figure 3.

Figure 4: Wealth, labor supply and welfare by unemployment insurance replacement rate.

quit their jobs. The moral hazard effects of unemployment insurance thus extend beyond search and saving.

In principle, redistributive concerns may be driving the finding of an optimal replacement rate of 0%, particularly since unemployment insurance is a relatively weak redistributive device when a large fraction of the population is married (see Section 6.6). However, Table 6 shows that this finding is not driven by redistributive concerns or by factors that are specific to married couples.

6.5 Optimal Mix of Social Assistance and Unemployment Insurance

Figure 5 shows the average lifetime welfare gains associated with various combinations of social assistance and unemployment insurance.[28] We find that the optimal policy mix combines social assistance that is 66% as generous as the baseline social assistance with a 0% unemployment insurance replacement rate. In other words, the optimal policy mix focuses on permanent universal social assistance, with no role for temporary earnings-related unemployment insurance. The optimal combination of social assistance and unemployment insurance differs fundamentally from the current German system, which combines time-limited earnings-related unemployment insurance with long-term universal social assistance. Instead, our optimal policy rule shares many features with assistance-orientated social support systems, such as the benefit system in the United Kingdom.

The average lifetime welfare gain from a move to the optimal combination of social assistance and unemployment insurance is 19,276 euros per person. This represents and increase of around 6,000 euros per person on the gain obtained from optimizing the generosity of social assistance alone, and an increase of around 7,800 euros per person on the gain obtained from optimizing the generosity of unemployment insurance alone.

Figure 5 illustrates two related aspects of interdependence between social assistance and unemployment insurance. First, the optimal social assistance generosity is 66% of the baseline level when the unemployment insurance replacement rate is 0%, while, as discussed in Section 6.3, the optimal social assistance generosity takes the lower value of 59% of the baseline level when the unemployment insurance replacement rate is fixed at 60%. Second, at low social assistance generosities the optimal unemployment insurance replacement rate is above zero – e.g., an optimal replacement rate of 20% applies when the social assistance income floor is fixed at either 5% or 10% of the baseline level.

6.6 Optimal Policy and the Family

One contribution of this paper is to shed light on the optimal design of social assistance and unemployment insurance while recognizing the marital composition of the population. Marital status is relevant to program design because the insurance, incentive and

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[28] We continue to consider policy environments that are revenue equivalent to the baseline system (see footnote 26). We do not illustrate the welfare effects associated with social assistance income floors below 5% of the baseline level because the welfare change becomes strongly negative as both the replacement rate and the social assistance income floor approach zero. In unreported analysis, we computed welfare gains from replacement rates of 10%, 30%, 40%, 50% and 70% in conjunction with social assistance generosities ranging from 0% to 100% of the baseline level. All of these program combinations were found to have less favorable welfare effects than the most favorable of the illustrated policies.
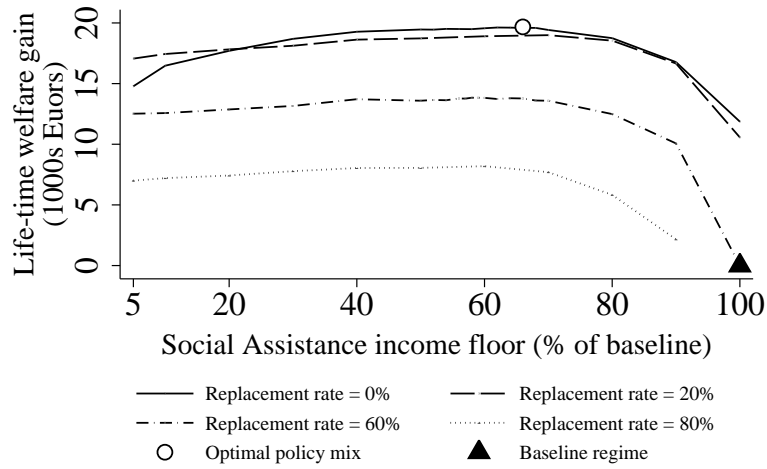
Note: See footnote 28 and note to Figure 3.

Figure 5: Lifetime welfare gains from combined adjustments in the generosities of social assistance and unemployment insurance.

redistributive effects of social assistance and unemployment insurance depend on household structure. As for singles, unemployment insurance provides married individuals with short-term partial earnings replacement following job loss, and saving, search and voluntary quits are subject to moral hazard effects. However, because unemployment insurance benefits are paid to non-employed individuals with a working spouse, the presence of married couples in the population weakens the redistributive effect of unemployment insurance. Social assistance benefits, meanwhile, are restricted to individuals who would otherwise be poor after accounting for both spouses' earnings. Social assistance, therefore, does not provide insurance against job loss when the spouse is employed and, correspondingly, the moral hazard effects of social assistance on saving, search and voluntary quits are weaker for married individuals than for singles. However, because the benefits are focused on households rather than individuals, social assistance remains strongly redistributive in the presence of married couples.

Differences in risk exposure and intra-household insurance according to marital status constitute further reasons for the optimal generosities of social assistance and unemployment insurance to depend on the family circumstances of the population. In married couples, wage risk and employment risk are pooled, and additional intra-household insurance is available from shared wealth and family labor supply. Insurance from family labor supply arises from both an income effect – the spouse may have earnings that persist in the face of the individual's own wage or employment shock – and an adjustment effect, where a married couple may adjust one spouse's labor supply in response to the other spouse's wage and employment shocks.

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As a final step, we explore the impact of the family on the optimal design of social assistance and unemployment insurance. In particular, we compare optimal program generosities for a society of always-single individuals and for a society in which individuals marry and divorce with the empirical probabilities (see Appendix A.1). We explore the impact of the family on the optimal single-program generosities, i.e., the optimal unemployment insurance replacement rate, given the baseline social assistance system, and vice versa. We also consider the role of the family in driving the optimal mix of social assistance and unemployment insurance generosities. We disaggregate our analysis by education, and this informs on how education-based redistributive concerns and education-based variation in the demand for social insurance and assistance play into the optimal policy calculations.

Table 6 presents optimal program generosities according to the distributions of education and marriage in the population. Panel A shows that the optimal single-program generosity of social assistance for a society of always-single low-educated individuals is 80% of the baseline level, while a lower optimal single-program generosity of 66% of the baseline level applies to a society of always-single high-educated individuals. This difference by education reflects that high-educated individuals place a relatively low value on insurance from social assistance because of their relatively high wages, low job destruction risk, and high likelihood of being eligible for generous unemployment insurance benefits. When low-educated and high-educated always-single individuals are combined into one society, a redistributive motive arises and the optimal single-program generosity of social assistance is 72% of the baseline level. The optimal single-program unemployment insurance replacement rate is 0% for single individuals, irrespective of education. Turning to the optimal mix of social assistance and unemployment insurance generosities, we find that, irrespective of education, the optimal combination of benefits for single individuals entails moderately generous social assistance and no unemployment insurance.[29]

A comparison of Panels A and B of Table 6 shows that introducing marriage and divorce at the empirical rates markedly reduces the optimal single-program generosities of social assistance. For example, starting with a society of always-single low-educated individuals and introducing marriage and divorce according to the empirical probabilities

[29]Comparing the optimal single-program generosity of social assistance with the generosity of social assistance in the optimal mix shows that the optimal generosity of social assistance is essentially invariant with respect to the unemployment insurance replacement rate. This reflects that social assistance is withdrawn one-for-one against unemployment insurance benefits and, for low-wage individuals, has a similar value to unemployment insurance benefits. In contrast, the optimal generosity of social assistance for high-educated individuals depends strongly on the unemployment insurance replacement rate, which reflects that the baseline unemployment insurance system provides insurance to the high educated, beyond that provided by social assistance. Redistributive concerns drive the welfare-maximizing generosity of social assistance in the optimal mix above the education-specific optimal generosities.

	Optimal single-program generosities		Optimal mix
	Social assistance	Replacement	Social assistance/
	(% of baseline)	rate (%)	Replacement rate

Panel A: Single individuals only (zero probability of marriage):

Low-educated individuals	80	0	81/0
High-educated individuals	66	0	80/0
High and low educ'd individuals	72	0	84/0

Panel B: Single and married individuals (empirical marriage and divorce probabilities):

Low-educated individuals	66	0	64/10
High-educated individuals	58	0	67/10
High and low educ'd individuals	59	0	66/0

Note: Optimal single-program generosities refer to the optimal social assistance generosity, given baseline unemployment insurance, and vice versa. Optimal mix refers to the welfare-maximizing combination of the social assistance income floor, expressed as a percentage of the baseline, and the Unemployment Insurance replacement rate, expressed as a percentage. In Panel B, where marriage and divorce occur with the empirical probabilities, 68% of low-educated individuals and 60% of high-educated individuals aged 16–65 years reside in married households. In the mixed-education society with marriage and divorce, individuals match assortatively as described in Appendix A.2.

Table 6: Effect of the family on the optimal generosities of social assistance and unemployment insurance.

reduces the optimal single-program generosity of social assistance from 80% to 66% of the baseline level, a reduction of 17.5%. Introducing marriage and divorce reduces the optimal single-program generosity of social assistance by 12% for high-educated individuals. The increasing importance of marriage to the optimal generosity of social assistance as education decreases reflects that the intra-household insurance offered by marriage has relatively high value to low-educated individuals, who have low wages and high employment risk. For the most relevant case of a society containing the empirical frequencies of high-educated and low-educated individuals, introducing marriage and divorce reduces the optimal single-program generosity of social assistance from 72% to 59% of the baseline level, a reduction of 18%. The change in the optimal generosity of social assistance that arises when high-educated and low-educated individuals who marry and divorce are com-

bined into one society reflects redistributive concerns and changing marriage patterns, as individuals start to marry between, as well as within, education groups. The change in marriage patterns affects risk exposure and intra-household insurance options, and it mediates the redistributive motive. Meanwhile, given the baseline social assistance system, the optimal single-program unemployment insurance replacement rate remains at 0% following the introduction of marriage and divorce according to the empirical probabilities.

With the introduction of marriage, the optimal mix continues to be assistance-oriented, and is characterized by moderately generous social assistance and, depending on the distribution of education, either low or zero unemployment insurance benefits. Specifically, within education groups the optimal mix features unemployment insurance benefits with a replacement rate of 10%. The insurance incentive trade-off therefore favors the provision of a small amount of insurance against employment shocks to individuals with a working spouse, which cannot be provided by household-level social assistance benefits because of the means-testing of these benefits against the spouse's earnings. Redistributive concerns, partly mediated by changes in marriage patterns, arise for a society of high-educated and low-educated single and married individuals. Consequently, combining high-educated and low-educated individuals into one society decreases the optimal replacement rate from 10% to 0%: unemployment insurance is no longer part of the optimal mix, and households rely solely on the more redistributive social assistance.

As for the single-program generosity of social assistance, introducing marriage and divorce reduces the optimal generosity of social assistance in the optimal mix, with the effect of marriage being larger for low-educated individuals than for high-educated individuals. Quantitatively, moving from a society of always-single individuals to a society in which individuals marry and divorce according to the empirical probabilities reduces the optimal generosity of social assistance benefits in the optimal mix by 16–22%, depending on education. In summary, the family context is an important determinant of the optimal generosity of social assistance benefits, both when the unemployment insurance system maintains the baseline replacement rate of 60% and when the generosities of social assistance and unemployment insurance are considered jointly. In contrast, the optimal unemployment insurance replacement rate is zero or close to zero, irrespective of the distribution of education and marital status in the population, and irrespective of whether we focus the design of unemployment insurance in isolation or consider the optimal mix of social assistance and unemployment insurance benefits.

As explained in Section 6.1, the dependence of the optimal generosity of social assistance on the family context reported in Table 6 arises from heterogeneity by family type in the insurance, incentive, and redistributive effects of social programs, in the pooling of risks within the household and in the availability of intra-household insurance from shared savings and family labor supply. Here, we explore the cross-spouse labor supply response to job destruction, and we thus make a link between the family labor supply
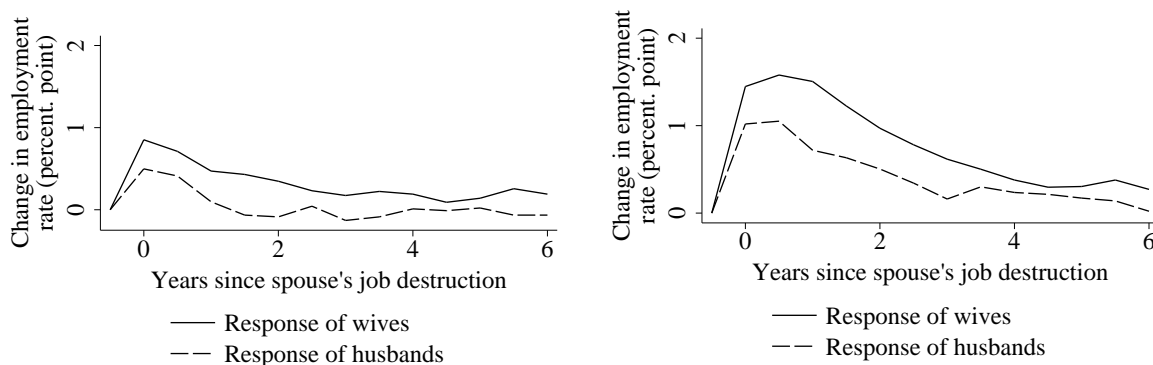
(a) With estimated leisure complementarities.   (b) Without leisure complementarities.

Note: The cross-spouse labor supply response is obtained by considering in turn the age points 20, 30 and 40 years, and using the estimated model to simulate optimal household behavior when one spouse is not subject to a job destruction at the age point of interest and when the same spouse is subject to an unanticipated job destruction at the age point of interest. The figures illustrate the spousal response, averaged over the three age points. Employment is defined as either full-time or part-time work. We consider optimal household behavior in each scenario, and therefore the spouse subject to a job destruction may subsequently return to employment. Results refer to households that remained married between 6 months before and 6 years after the age point of interest.

Figure 6: Employment response to spouse's job loss.

process and the welfare effects of program reforms. Figure 6(a) illustrates how the labor supply of wives and husbands responds to their partners' job destructions when individuals enjoy the estimated degree of complementarity between the spouses' leisure times. These results were obtained by simulating couples' behavior from the estimated model and thus account for the effect of job destructions on both spouses' labor supply behavior. The cross-spouse employment response appears to be important in mitigating the effects of job destruction. Both husbands and wives increase employment contemporaneously in response to their spouses' job destructions: the employment rate of husbands increases by 0.50 percentage points in immediate response to their wives' job destructions, while the employment rate of wives increases by 0.85 percentage points in the period of their husbands' job destructions.[30] Furthermore, the spousal employment response is persistent, particularly among women; for example, the husband's job destruction increases the probability of the wife being in employment 6 years later by 0.19 percentage points.

Figure 6(b) shows that removing between-spouse leisure complementarities increases

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[30]According to the timing of events in the model, shown in Figure 1, the household members observe job destructions for both spouses prior to making search and labor supply decisions. It is therefore possible for the couple to increase one spouse's labor supply contemporaneously in response to the other spouse's job destruction.

the immediate cross-spouse labor supply response to job destruction and increases the persistence of the cross-spouse response: on average, shutting down between-spouse leisure complementarities increases the employment response of wives to their husbands' job destructions by a factor of 2.24 and increases the response of husbands to their wives' job destructions by a factor of 1.87. These findings reflect that between-spouse leisure complementarities moderate the cross-spouse labor supply response by providing a utility benefit to joint non-work.[31] The change in the cross-spouse labor supply response to job loss that arises from the removal of leisure complementarities suggests that the preference for joint non-work is itself an important input to the optimal design of social programs.

7   Conclusion

There are large international differences in how social insurance and social assistance programs are combined to support households facing job loss and other adverse circumstances. The US, Germany and France, for example, combine temporary earnings-related benefits with permanent or longer-term social assistance that is not based on previous earnings. Meanwhile, social support in the UK is provided primarily through universal social assistance. In this paper, we have explored how best to combine unemployment insurance and social assistance, given intra-household insurance from savings and family labor supply. We have also investigated the importance of the family for the optimal design of social insurance and assistance programs.

Our main finding is that assistance-orientated social support systems dominate insurance-based programs of support. In the most preferred social insurance and assistance system, permanent universal social assistance provides income of last resort to low-income households, and there is little or no role for temporary earnings-related unemployment insurance. The optimal system resembles the UK's assistance-orientated framework for social support, and differs fundamentaly from the existing programs of social support in the US, Germany and France, which combine insurance and assistance benefits. We also show that the presence of married couples in the population markedly decreases the optimal generosity of social assistance. This result reflects that married couples optimally draw on intra-household insurance from family labor supply and increase one spouse's labor supply in response to the other spouse's job loss.

Our analysis provides several further insights that are relevant to future research. In particular, we show that the use of family labor supply as an intra-household insurance device depends on the strength of complementarity between the leisure times of the husband and wife, which rewards coordination on joint non-work. Based on this result, we argue

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[31]For empirical evidence on the relevance of leisure complementarities to hours of work, see e.g., Goux and Petrongolo (2014).

that understanding the policy relevance of intra-household insurance requires recognition of the preference-based drivers of couples' behavior. Our results also suggest that there are substantial interdependencies between social assistance programs that are targeted at low-income populations, such as programs that guarantee a minimum household income, and social insurance programs that provide earnings-related benefits, such as unemployment insurance, with the optimal generosity of one program depending on the design of other social support programs. Indeed, in our setting we found minimal justification for temporary earnings-related benefits, provided that social assistance protects households against adverse events.

Appendix (For Online Publication)

A Marriage, Divorce, Assortative Mating, Fertility, and Job Destructions

This appendix describes the exogenous processes that determine marital status, assortative mating, fertility outcomes and job destructions. We also describe how the parameters of these processes are estimated prior to estimation of the life-cycle model.

A.1 Marriage and Divorce

Marriage occurs with a probability that depends on the individual's gender, age and education, and a married couple divorces with a probability that depends on the age and education of the female spouse. Furthermore, women may marry only prior to age 62.5 years, while men may marry only prior to age 65 years. Divorce may occur only prior to the wife reaching age 62.5 years.

Marriage probabilities are estimated using Lowess regressions of marriage on age, using a sample of individuals who were single in the previous period. Similarly, divorce probabilities are estimated using Lowess regressions of divorce on the age of the female spouse, using a sample of women who were married in the previous period. Figure 7 shows the estimated semiannual marriage and divorce probabilities.
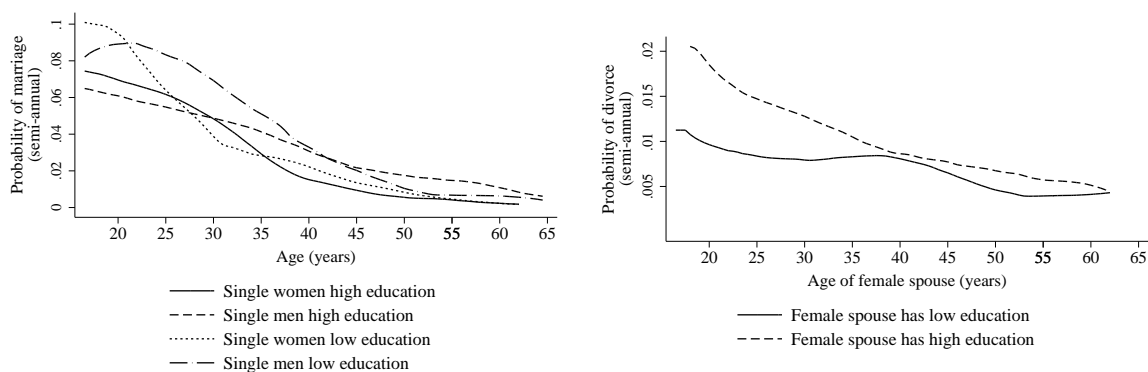
Note: Estimation uses the SOEP sample for 1991–2005 (see Table 1). High education is defined as 12 or more years of education.

Figure 7: Semiannual marriage and divorce probabilities.

A.2 Assortative Mating

We model education-based assortative mating by allowing the educational attainment of an individual's new spouse to depend on the individual's own level of education. In particular, the years of education of the new spouse married to individual g (SEduc_g) is given by

$$\text{SEduc}_g = \min\{\max\{\text{SEduc}_g^*, 10\}, 19\}, \tag{20}$$

where SEduc_g^* is a normally distributed latent variable with a mean that depends on g's own level of education. Specifically,

$$\text{SEduc}_g^* \sim N(\lambda_1 + \lambda_2 \text{Male}_g + \lambda_3 \text{Education}_g \times \text{Male}_g + \lambda_4 \text{Education}_g \times (1 - \text{Male}_g), \sigma_S^2), \tag{21}$$

where Male_g indicates g's gender and Education_g denotes g's years of education.

We estimate the parameters of (21) using a sample of 1,532 newly formed married couples and obtain the following results (standard errors in parentheses): $\widehat{\lambda}_1 = 7.860(0.541)$; $\widehat{\lambda}_2 = 1.991(1.001)$; $\widehat{\lambda}_3 = 0.520(0.036)$; $\widehat{\lambda}_4 = 0.640(0.037)$; and $\widehat{\sigma}_S^2 = 2.332(0.048)$. The large and significant estimates of λ_3 and λ_4 point to substantial education-based assortative mating mating.

A.3 Fertility

The first child arrives with a probability that depends on the woman's age, education and marital status. The probability of birth of the first child is assumed to be zero for women below 18 years of age or for women 38 years and older. For women aged 18-37.5 years, the probability of birth of the first child is estimated using Lowess regressions of a first-birth indicator on age. Figure 8 illustrates the estimated semiannual probabilities of the birth of the first child.

A second child is assumed to arrive three years after the first child, and no further children are born. Children reside in the mother's household until they reach age 18 years, at which point they leave the household. The age of the first-born child summarizes fully the number and age of a woman's children, and therefore the age of the first-born child is the only child-related variable included in the state space.

A.4 Job Destructions

We estimate the job destruction probabilities using information in the annual SOEP surveys on the reasons that newly non-employed individuals left previous employment. Using this information, we identify involuntary separations, defined as separations attributed to layoff, plant closure, or the termination of a temporary contract. We estimate the probability of an involuntary separation conditional on a transition out of employment. We also
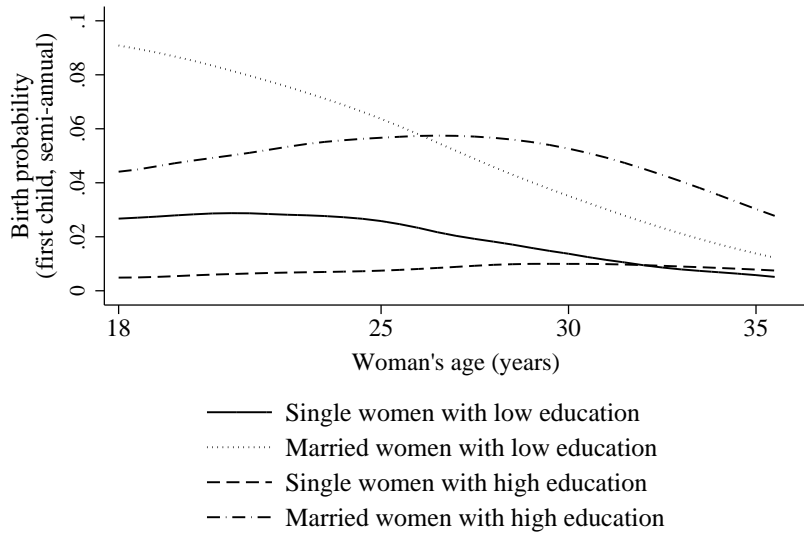
Note: Estimation uses the SOEP sample for 1991–2005 (see Table 1). The sample is further restricted to women 18-37.5 years of age without preexisting children. High education is defined as 12 or more years of education.

Figure 8: Semiannual birth probabilities.

estimate the semiannual probability of a transition out of employment. Both probabilities are allowed to vary according to the individual's gender, age, education and marital status. Table 7 reports the estimated job destruction probabilities, obtained by taking the product of the probability of an involuntary separation, conditional on a transition out of employment, and the semiannual probability of a transition out of employment.

| | Single individuals | |
	Women	Men
High education and age≥50 years	0.041	0.032
High education and age<50 years	0.017	0.018
Low education and age≥50 years	0.024	0.042
Low education and age<50 years	0.024	0.020
	Married individuals	
	Women	Men
High education and age≥50 years	0.029	0.014
High education and age<50 years	0.019	0.006
Low education and age≥50 years	0.039	0.029
Low education and age<50 years	0.020	0.020

Note: Estimation uses the SOEP sample for 1991–2005 (see Table 1).
High education refers to 12 or more years of education.

Table 7: Semiannual job destruction probabilities.

B   Social Assistance Income Floor

The social assistance income floor depends on marital status and on the number and ages of any children present in the household. We represent the social assistance income floor by the product of a baseline generosity, G, and a household equivalence scale, E:

$$\text{SAFloor} = G \times E(\text{Married}, \text{AgeFirstChild}), \tag{22}$$

where Married is an indicator for the household being a married couple, and AgeFirstChild is the age of the woman's first-born child (as discussed in Appendix A.3, this variable summarizes fully the number and age of a woman's children). The household equivalence scale is normalized to one for a single household without children, and is incremented for the presence of additional adults and children. Specifically,

$$\begin{aligned}
E(\text{Married}, \text{AgeFirstChild}) & = 1 + 0.73\text{Married} + 0.5(\#\text{Ch0} - 6) + 0.65(\#\text{Ch7} - 13) \\
& \quad + 0.9(\#\text{Ch14} - 17) + 0.05(\#\text{Ch0} - 6) \times (1 - \text{Married}) \\
& \quad + 0.4 \times \mathbf{1}(\text{AnyCh0} - 17) \times (1 - \text{Married}). \tag{23}
\end{aligned}$$

In the above, the terms (#ChX – Y) refer to the number of children aged between X and Y years inclusive, and $\mathbf{1}(\text{AnyCh0} - 17)$ is an indicator for the presence of any child age 17 years or younger in the household. The baseline generosity, G, is 600 euros per month.

C Social Security Contributions, Income Tax, Pensions, Child Benefits, and Child-Care Costs

This appendix describes our modeling of Social Security Contributions, income tax, pensions, child benefits, and child-care costs. The specification is based on the German system. Social assistance and unemployment insurance benefits are described above in Sections 2.5.2 and 2.5.3.

Individuals pay Social Security Contributions (SSC) for health, unemployment, and public pension benefits. SSC amount to about 20% of gross earned income below a cap of around 4,300 euros per month. Employers are required to match employees' contributions.[32] In contrast to SSC, income tax is computed at the household level: for a single household, income tax is based on the individual's taxable income, while for a couple household, income is taxed jointly and the tax is based on the average of the spouses' taxable incomes. Taxable income comprises gross income from employment above an exemption threshold and gross interest income above a disregard, less SSC. The income tax function is a smooth progressive function of average household taxable income above an exemption threshold. Conditional on average household taxable income, a couple household's income tax liability is twice that of a single household. Households pay a further tax (Solidaritaetszuschlag) of 5.5% of the household's income tax liability.

Under the German pension system, individuals accumulate pension entitlement for each year of work, with the entitlement being roughly proportional to annual earnings (for further details see Börsch-Supan and Wilke, 2004, and Haan and Prowse, 2014). Mirroring this, in our model a retired individual receives an annual pension that is proportional to his or her approximate lifetime earnings:

$$\text{Pension}_{g,t} = \Xi \times \text{Exp}_{g,t} \times W_g(\text{Education}_g, 0.5 \times \text{Exp}_{g,t}, \overline{\kappa}) \quad \text{for} \quad g = i, j. \quad (24)$$

In the above, Exp continues to denote years of experience, and the function $W_g()$ denotes the gender-specific market wage function (5) evaluated at the individual's education, average experience over the life-cycle, and the population average of the wage unobservable, $\overline{\kappa}$.[33] Reflecting the pension system that was effective during the sample period, we set the proportionality factor Ξ to 20.

The model includes child benefits worth 150 euros per month for each dependent child. Social assistance benefits, which include a child-related component, are withdrawn at a rate of 100% against child benefits; however, child benefits do not affect unemployment insurance benefits. We also model child-care costs. We assume that a married couple

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[32]We account for individual and employer Social Security Contributions when calculating revenue-equivalent policy reforms (Section 6 and footnote 26).

[33]The population average of the wage unobservable, $\overline{\kappa}$, is computed using the steady state distribution. See footnote 11.

with one or more pre-school aged children must pay for full-time child-care if both spouses work full-time. Part-time child-care costs are incurred if the wife works part-time and the husband works full-time. Similarly, a single woman with one or more pre-school aged children must pay child-care costs reflecting her hours of work. Based on Wrohlich (2011), we estimate expected monthly child-care costs for a child younger than 3 years at 183 euros for part-time care and 397 euros for full-time care. The corresponding figures for a child aged between 3 and 6 years are 90 euros and 167 euros. These figures reflect the relatively limited access to subsidized child-care for infants and assume a price of 5 euros per hour for unsubsidized child-care.

D   Optimal Life-Cycle Behavior

We characterize optimal life-cycle behavior using the value functions for single and married women and men. Given the forward-looking nature of the dynamic problem, the optimization problems facing singles and married couples are interdependent: a single individual's decisions are partly driven by the expected consequences if he or she marries in the future, and a married couple's decisions are influenced by the expected consequences for each spouse in the event of divorce.

D.1   Singles

First, consider a single woman. The woman's choice problem ends when she reaches the compulsory retirement age, $\widetilde{T}$. From this time onward the woman cannot search or work, and she consumes pension and social assistance benefits plus the actuarially fair annuity value of household wealth at the compulsory retirement age.[34] The woman's terminal value function is given by

$$\overline{V}^{Fs}(\Psi_{i,\widetilde{T}}) = \mathbb{E}\left[\sum_{\tau=\widetilde{T}}^{\overline{T}^F} \delta^{(\tau-\widetilde{T})} u^F(m_{i,\emptyset,\widetilde{T}}, d_{i,\widetilde{T}}, d_{\emptyset,\widetilde{T}+\Delta}) \,\middle|\, \Psi_{i,\widetilde{T}}\right], \qquad (25)$$

where $d_{i,\widetilde{T}}$ takes the value RT, indicating that the woman is retired, $d_{\emptyset,\widetilde{T}+\Delta}$ denotes the absence of a husband, $\overline{T}^F$ denotes the woman's age at death, and $\Psi_{i,t}$ denotes the woman's

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[34]Annuity values are computed assuming a real interest rate of 3%. The annuity calculation for a single household is based on the individual's gender-specific life expectancy at the compulsory retirement age, while the annuity calculation for a married couple is based on the wife's life expectancy at the compulsory retirement age.

state variables at age t.[35]

In each period prior to the compulsory retirement age, a single woman's optimization problem proceeds in two stages. First, search intensity is optimized. A job offer may arrive, and the set of feasible labor supply choices is observed by the household. Second, the household optimizes consumption and labor supply behavior. This within-period problem is solved backwards: we determine optimal consumption and labor supply behavior for each possible set of feasible labor supply choices, and then solve for the optimal search intensity, taking into account the effect of search on the probability of employment constraints.

Prior to the compulsory retirement age, the labor supply-specific value functions for woman i are given by

$$
\begin{aligned}
V_t^{Fs}(d|s, \Psi_{i,t}) &= U^F(m^*(d), d, d_{\emptyset,t+\Delta}, s, \varepsilon_{i,t}) + \\
&\quad \delta \mathbb{E}\left[\phi_{t+1}^{Fs} V_{t+1}^{Fs}(\Psi_{i,t+1}) + (1 - \phi_{t+1}^{Fs}) V_{t+1}^{Fc}(\Psi_{i,t+1}, \Phi_{j,t+\Delta+1})\middle| \Psi_{i,t}, d\right], \\
&\quad \text{for } d \in \mathcal{D}^F.
\end{aligned}
\tag{26}
$$

In the above, $\delta = \sqrt{0.98}$ is the semiannual subjective time discount factor, s denotes the woman's search intensity, and $\Phi_{j,t}$ denotes potential future husband j's age-t state variables.[36] The single woman's value function reflects the likelihood of marriage in the next period: her value function in the next period is the sum of the probability of remaining single, ϕ_{t+1}^{Fs}, times the single woman's value function at age $t + 1$, $V_{t+1}^{Fs}(\Psi_{i,t+1})$, and the probability of marriage in the next period times the married woman's value function at age $t+1$, $V_{t+1}^{Fc}(\Psi_{i,t+1}, \Phi_{j,t+\Delta+1})$. The value function for a married woman is defined in Section D.2. Last, $m^*(d)$ is the consumption choice that maximizes the labor supply-specific value function, subject to the intertemporal budget constraint and the non-negativity constraint on household wealth.

We assume that individuals' expectations about the observable characteristics of future spouses reflect the modal in-sample pattern of marriage matching: an individual expects that his or her future spouse will enter the marriage with the same education, employment status, and unemployment insurance entitlement and eligibility as him or herself; individuals expect that the husband will enter the marriage with 7% more experience and 5% more wealth than the wife; and a man expects his future wife to enter the marriage without preexisting children. Regarding the wage unobservables, an individual

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[35]Based on the German Human Mortality Database we estimate values of 80 and 73 for, respectively, $\overline{T}^F$ and $\overline{T}^M$. The woman's state space, $\Psi_{i,t}$, contains the following characteristics of the woman: age; education category; persistent wage type; unemployment insurance eligibility; unemployment insurance entitlement period; previous hours; job destruction status; labor supply status in the previous period; household wealth; current period preference shocks; and the age of the first-born child.

[36]The man's state space, $\Phi_{j,t}$, contains all variables that appear in the woman's state space (see footnote 35), except for previous hours and the age of the first-born child.

expects any future spouse to enter the marriage with the same wage unobservable as him- or herself.

We now characterize optimal labor supply behavior given the set of feasible choices, as determined by the outcome of search activities, job destructions, and the age-based restrictions on retirement eligibility. Let D_k^F for $k = 1, ..., K^F$ denote all possible sets of feasible labor supply choices. Given the set of feasible choices D_k^F, the single woman chooses the labor supply alternative with the highest choice-specific value function:

$$d_{i,t}^*(D_k^F) = \underset{d \in D_k^F}{\operatorname{argmax}} V_t^{Fs}(d|s, \Psi_{i,t}). \tag{27}$$

The single woman's optimal search intensity, $s_{i,t}^*$, is given by

$$s_{i,t}^* = \underset{s \in [0, 1/\chi_{i,t}]}{\operatorname{argmax}} \left\{ \sum_{k=1}^{K^F} P(D_k^F|s, \Psi_{i,t}) V_t^{Fs} \left(d_{i,t}^* \left(D_k^F \right) \middle| s, \Psi_{i,t} \right) \right\}, \tag{28}$$

where $P(D_k^F|s, \Psi_{i,t})$ is the probability of the set D_k^F of feasible labor supply choices given search intensity s. Evaluating the term in braces in (28) at the optimal search intensity, $s_{i,t}^*$, obtains the single woman's value function, $V_t^{Fs}(\Psi_{i,t})$. A single man's value function is obtained in the same way.

D.2 Married Couples

A married couple's choice problem ends when the wife reaches the compulsory retirement age, $\widetilde{T}$, and therefore when the husband is age $\widetilde{T} + \Delta$. Once the wife reaches the compulsory retirement age, neither spouse can search or work, and the household consumes pension and social assistance benefits plus the actuarially fair annuity value of household wealth at the time when the wife reached the compulsory retirement age. The terminal value for woman i in married couple (i, j) is given by

$$\overline{V}^{Fc}(\Psi_{i,\widetilde{T}}, \Phi_{j,\widetilde{T}+\Delta}) = \mathbb{E}\left[\sum_{\tau=\widetilde{T}}^{\overline{T}^F} \delta^{(\tau - \widetilde{T})} u^F(m_{i,j,\widetilde{T}}, d_{i,\widetilde{T}}, d_{j,\widetilde{T}+\Delta}) \middle| \Psi_{i,\widetilde{T}}, \Phi_{j,\widetilde{T}+\Delta} \right], \tag{29}$$

and the terminal value for man j in married couple (i, j) is given by

$$\overline{V}^{Mc}(\Psi_{i,\widetilde{T}}, \Phi_{j,\widetilde{T}+\Delta}) = \mathbb{E}\left[\sum_{\tau=\widetilde{T}+\Delta}^{\overline{T}^M} \delta^{(\tau - \widetilde{T} - \Delta)} u^M(m_{i,j,\widetilde{T}}, d_{i,\widetilde{T}}, d_{j,\widetilde{T}+\Delta}) \middle| \Psi_{i,\widetilde{T}}, \Phi_{j,\widetilde{T}+\Delta} \right]. \tag{30}$$

In the two above equations, $d_{i,\widetilde{T}}$ and $d_{j,\widetilde{T}+\Delta}$ take the value RT, indicating that both spouses are retired. The married couple's objective function is formed from an α-weighted average of the spouses' utilities. Therefore, the terminal value function for the married couple takes the form:

$$\overline{V}^{FM}(\Psi_{i,\widetilde{T}}, \Phi_{j,\widetilde{T}+\Delta}) = \alpha \overline{V}^{Fc}(\Psi_{i,\widetilde{T}}, \Phi_{j,\widetilde{T}+\Delta}) + (1 - \alpha)\overline{V}^{Mc}(\Psi_{i,\widetilde{T}}, \Phi_{j,\widetilde{T}+\Delta}). \tag{31}$$

In each period prior to the wife reaching the compulsory retirement age, the couple's optimization problem proceeds in two stages, as for singles. First, search intensities are optimized and job offers may arrive. Second, the household optimizes consumption and labor supply behavior. We have the following labor supply-specific value functions for the married couple prior to the wife reaching the compulsory retirement age:

$$
\begin{aligned}
V_t^{FM}(d^F, d^M | s^F, s^M, \Psi_{i,t}, \Phi_{j,t+\Delta}) &= \alpha U^F(m^*(d^F, d^M), d^F, d^M, s^F, \varepsilon_{i,t}) \\
&\quad + (1-\alpha)U^M(m^*(d^F, d^M), d^F, d^M, s^M, \varepsilon_{j,t+\Delta}) \\
&\quad + \delta \mathbb{E}\Big[(1 - \phi_{t+1}^c)\big(\alpha V_{t+1}^{Fs}(\Psi_{i,t+1}) + (1-\alpha)V_{t+\Delta+1}^{Ms}(\Phi_{j,t+\Delta+1})\big) \\
&\quad + \phi_{t+1}^c V_{t+1}^{FM}(\Psi_{i,t+1}, \Phi_{j,t+\Delta+1})\Big| \Psi_{i,t}, \Phi_{j,t+\Delta}, d^F, d^M\Big],
\end{aligned}
$$

$$
\text{for } d^F \in \mathcal{D}^F \text{ and } d^M \in \mathcal{D}^M. \tag{32}
$$

In the above, $\phi_{i,t+1}^c$ is the probability that the spouses remain married, and $m^*(d^F, d^M)$ denotes the consumption choice that maximizes the labor supply-specific value function, again subject to the intertemporal budget constraint and the non-negativity constraint on household wealth. The married couple's value function reflects the possibility of divorce: the married couple's value function in the next period is weighted by the probability that the marriage survives, and the complementary probability is attached to an α-weighted average of value functions of single women and men (see Section D.1). van der Klaauw and Wolpin (2008) and Fernández and Wong (2014) use similar preference specifications in studies of, respectively, the effect of Social Security on household retirement behavior and the effect of divorce risk on female labor force participation.

Let D_k^c for $k = 1, ..., K^c$ denote all possible sets of feasible labor supply choices for a married couple. Given the set of feasible labor supply choices D_k^c, the household chooses the labor supply alternative with the highest choice-specific value function:

$$
(d_{i,t}^*(D_k^c), d_{j,t+\Delta}^*(D_k^c)) = \underset{(d^F, d^M) \in D_k^c}{\operatorname{argmax}} V_t^{FM}\left(d^F, d^M | s^F, s^M, \Psi_{i,t}, \Phi_{j,t+\Delta}\right). \tag{33}
$$

The wife's and husband's optimal search intensities are given by

$$
(s_{i,t}^*, s_{j,t+\Delta}^*) =
$$
$$
\underset{\substack{s^F \in [0, 1/\chi_{i,t}] \\ s^M \in [0, 1/\chi_{j,t+\Delta}]}}{\operatorname{argmax}} \left\{ \sum_{k=1}^{K^c} P(D_k^c | s^F, s^M) V_t^{FM}\left(d_{i,t}^*(D_k^c), d_{j,t+\Delta}^*(D_k^c)\middle| s^F, s^M, \Psi_{i,t}, \Phi_{j,t+\Delta}\right) \right\}, \tag{34}
$$

where $P(D_k^c | s^F, s^M)$ is the probability of choice set D_k^c, given search intensities s^F for the wife and s^M for the husband.

Last, we split the married couple's value function into value functions for the wife and husband – as described in (26), the value functions for married women and men appear

in the single household's value function. For a married woman,

$$V_t^{Fc}(\Psi_{i,t}, \Phi_{j,t+\Delta}) = \sum_{k=1}^{K^c} P(D_k^c | s_{i,t}^*, s_{j,t+\Delta}^*) V_t^{Fc} \left(d_{i,t}^*(D_k^c), d_{j,t+\Delta}^*(D_k^c) \big| s_{i,t}^*, s_{j,t+\Delta}^*, \Psi_{i,t}, \Phi_{j,t+\Delta} \right), \quad (35)$$

where

$$\begin{aligned}
V_t^{Fc} &\left(d_{i,t}^*(D_k^c), d_{j,t+\Delta}^*(D_k^c) \big| s_{i,t}^*, s_{j,t+\Delta}^*, \Psi_{i,t}, \Phi_{j,t+\Delta} \right) \qquad\qquad (36)\\
&= U^F(m^*(d_{i,t}^*(D_k^c), d_{j,t+\Delta}^*(D_k^c)), d_{i,t}^*(D_k^c), d_{j,t+\Delta}^*(D_k^c), s_{i,t}^*, \varepsilon_{i,t})\\
&\quad + \delta \mathbb{E}\left[(1 - \phi_{t+1}^c) V_{t+1}^{Fs}(\Psi_{i,t+1}) + \phi_{t+1}^c V_{t+1}^{Fc}(\Psi_{i,t+1}, \Phi_{j,t+\Delta+1}) \Big| \Psi_{i,t}, \Phi_{j,t+\Delta}, d_{i,t}^*(D_k^c), d_{j,t+\Delta}^*(D_k^c) \right].
\end{aligned}$$

The value function for a married man may be derived in the same way.

E   Auxiliary Model Parameters

Tables 8 and 9 describe the auxiliary model parameters and discuss identification of the parameters of the life-cycle model described in Section 2.

Auxiliary model parameters	Number	Structural parameters primarily identified, and notes
Group 1: Mean log wage for: all women; women with high education; women with high experience; women whose youngest child under 3 years of age; women whose youngest child is aged 3 or over and under 6 years; women whose husband has high education.	6	Intercept and coefficients on education and experience in the wage process for women ($\beta_1^F, \beta_2^F, \beta_3^F$). Note: the inclusion of information on wages specifically for women with children and with a highly educated husband ensures the separation of selection effects from determinants of the market wage.
Group 2: Parameters in Group 1 estimated for men.	6	$\beta_1^M, \beta_2^M, \beta_3^M$.
Group 3: Variance of log wage for women and for men.	2	Standard deviation of wage measurement error for women and men ($\sigma_{\nu F}, \sigma_{\nu M}$).
Group 4: Correlation of spouses' contemporaneous log wages.	1	Between-spouse correlation of persistent wage shocks (ϱ).
Group 5: Covariance between log wage at t and $t-2$ for women and for men.	2	Loadings on persistent unobservable in the wage processes for women and men (β_4^F, β_4^M).
Group 6: Log odds ratio of the probability that a woman who was employed at $t-2$ with a log wage of less than 2.5 experiences a wage increase between periods $t-2$ and t; log odds ratio of the probability that a woman who was employed at $t-2$ with a log wage greater than 2.5 experiences a wage decrease between periods $t-2$ and t.	2	Parameters determining the probabilities of persistent shocks to women's wages (θ_0^F, θ_1^F).
Group 7: Parameters in Group 6 estimated for men.	2	θ_0^M, θ_1^M.
Group 8: Log odds ratios of the probabilities of a voluntary quit at time t and of full-time employment at time t, given employed at time $t-1$ for: single and married women aged under 50; and single and married women aged 50–65. Log odds ratios of probabilities of full-time and part-time employment for single and married women: whose youngest child is aged under 3 years; and whose youngest child is aged 3 or over and under 6 years.	16	Preference of women for consumption when working full-time or part-time ($\eta_{1,FT}^F, \eta_{2,FT}^F, \eta_{1,PT}^F, \eta_{2,PT}^F$). Note: With the exception of age effects, the employment-state specific consumption preference of married individuals is identified from information on singles.

Note: High experience is defined as 20 or more years of experience. We take the following steps to ensure that the same wage selection rules apply to the simulated sample and to the estimation sample: the simulated wage observations include measurement error; simulated wage observations are included only for employed individuals and only in the first half of each year (in the estimation sample, the wage is only observed at the time of annual interview, which typically falls between January and June); and simulated wage observations are excluded with the non-response probability observed in the estimation sample.

Table 8: Auxiliary model parameters I.

Auxiliary model parameters	Number	Structural parameters primarily identified, and notes
Group 9: Log odds ratio of the probability of a voluntary quit at time t given employed at time $t-1$ for: single and married men under 50 years of age; single and married men aged 50–65.	4	Preference of men for consumption when working full-time. $(\eta_{1,FT}^M, \eta_{2,FT}^M)$.
Group 10: Log odds ratios of the probabilities of full-time employment and part-time employment for: single women with high education and low experience; single women with high education and high experience; single women with high education and low experience; single women with low education and high experience; single women under 50 years of age; and single women aged 50–65. Same log odds ratios for married women.	20	Search productivity parameters for women $(\chi_1^F, \chi_2^F, \chi_3^F, \chi_4^F)$. Note: Given the employment-state specific preference for consumption, employment levels are informative about search productivity, which impacts the rate of transition into employment.
Group 11: Log odds ratio of the probability of full-time employment for: single men with high education and low experience; single men with high education and high experience; single men with high education and low experience; single men with low education and high experience; single men under 50 years of age; and single men aged 50–65. Same log odds ratios for married men.	10	Search productivity parameters for men $(\chi_1^M, \chi_2^M, \chi_3^M, \chi_4^M)$.
Group 12: Log odds ratios of the probability of husband non-employed and: wife working full-time; wife working part-time; and wife non-employed. Log odds ratios of the probability of husband working full-time and: wife working part-time; and wife non-employed.	5	Log odds ratio of the probability of joint non-employment informs on the between-spouse leisure complementarity parameter (η_3). The other log odds ratios in this group inform on the weight on woman's utility in couples' objective function (α).
Group 13: Mean household wealth for: single women under 50 years of age; single women aged 50–65; single women with high education; single men under 50 years of age; single men aged 50–65; single men with high education; married households where husband is under 50 years of age; married households where husband is aged 50–65; married households where husband has high education.	9	Coefficients of relative risk aversion for women and men (ρ^F, ρ^M).
Group 14: Log odds ratio of the probability of voluntary quit at time t given full-time employment at time $t-1$ for single and married men and women with: high experience and high education; high experience and low education; low experience and high education. Log odds ratio of the probability of voluntary quit at time t given employed at time $t-1$ and $t-2$ for single and married men and women. Log odds ratio of the probability of full-time employment at time t given employed at time $t-1$ and $t-2$ for single and married women.	24	Standard deviation of preference shocks $(\varsigma_{FS}, \varsigma_{FC}, \varsigma_{MS}, \varsigma_{MC})$. Note: Conditional on income, preferences do not depend on experience or education. Variation in behavior along these dimensions therefore provides identifying information about the scale of preference unobservables.

Note: See note to Table 8.

Table 9: Auxiliary model parameters II.

F   Internal Goodness of Fit

Mean of:	Single women		Married women	
	Observed	Simulated	Observed	Simulated
Full-time work | Age<50	0.54	0.54	0.29	0.30
Part-time work | Age<50	0.16	0.16	0.30	0.30
Full-time work | Age≥50	0.44	0.44	0.22	0.24
Part-time work | Age≥50	0.12	0.12	0.26	0.28
Full-time work | High educ. & High exp.	0.70	0.65	0.43	0.35
Part-time work | High educ. & High exp.	0.12	0.15	0.33	0.33
Full-time work | Low educ. & High exp.	0.49	0.52	0.35	0.33
Part-time work | Low educ. & High exp.	0.15	0.14	0.33	0.31
Full-time work | High educ. & Low exp.	0.57	0.56	0.28	0.28
Part-time work | High educ. & Low exp.	0.18	0.18	0.31	0.30
Voluntary quit | Age < 50 & Emp. at $t-1$	0.02	0.02	0.03	0.03
Voluntary quit | Age ≥ 50 & Emp. at $t-1$	0.04	0.04	0.03	0.03
Voluntary quit | High educ. & High exp. & Emp. at $t-1$	0.02	0.02	0.03	0.03
Voluntary quit | Low educ. & High exp. & Emp. at $t-1$	0.02	0.02	0.02	0.02
Voluntary quit | High educ. & Low exp. & Emp. at $t-1$	0.03	0.03	0.02	0.02
Voluntary quit | Emp. at $t-2$ & Emp. at $t-1$	0.03	0.02	0.04	0.04
Full-time work | Age < 50 & Emp. at $t-1$	0.75	0.73	0.48	0.48
Full-time work | Age ≥ 50 & Emp. at $t-1$	0.76	0.75	0.44	0.44
Full-time work | High educ. & High exp. & Emp. at $t-1$	0.77	0.74	0.47	0.47
Full-time work | Low educ. & High exp. & Emp. at $t-1$	0.83	0.78	0.55	0.48
Full-time work | High educ. & Low exp. & Emp. at $t-1$	0.74	0.74	0.50	0.49
Full-time work | Emp. at $t-2$ & Emp. at $t-1$	0.74	0.73	0.44	0.45
Full-time work | Age < 50 & Youngest child aged < 3	0.16	0.09	0.10	0.11
Part-time work | Age < 50 & Youngest child aged < 3	0.34	0.29	0.32	0.33
Full-time work | Age < 50 & 3 ≤ Youngest child aged < 6	0.29	0.21	0.15	0.17
Part-time work | Age < 50 & 3 ≤ Youngest child aged < 6	0.42	0.45	0.41	0.42

Note: Emp. refers to full-time and part-time employment combined. High exp. is 20 or more years of experience. High educ. is 12 or more years of education.

Table 10: Internal goodness of fit I: Labor supply of single and married women.

Mean of:		Single men		Married men	
		Observed	Simulated	Observed	Simulated
Full-time work | Age<50		0.76	0.75	0.82	0.83
Full-time work | Age≥50		0.59	0.54	0.61	0.63
Full-time work | High educ. & High exp.		0.76	0.63	0.79	0.81
Full-time work | Low educ. & High exp.		0.64	0.66	0.70	0.71
Full-time work | High educ. & Low exp.		0.81	0.83	0.92	0.91
Voluntary quit | Age<50 & Emp. at $t-1$		0.02	0.02	0.01	0.01
Voluntary quit | Age≥50 & Emp. at $t-1$		0.04	0.03	0.03	0.03
Voluntary quit | High educ. & High exp. & Emp. at $t-1$		0.02	0.02	0.01	0.02
Voluntary quit | Low educ. & High exp. & Emp. at $t-1$		0.02	0.03	0.02	0.02
Voluntary quit | High educ. & Low exp. & Emp. at $t-1$		0.02	0.02	0.02	0.03
Voluntary quit | Emp. at $t-2$ & Emp. at $t-1$		0.02	0.02	0.01	0.01

Note: See note to Table 10.

Table 11: Internal goodness of fit II: Labor supply of single and married men.

Mean of:	Observed	Simulated
Wealth | Single man age<50	0.26	0.35
Wealth | Single man age≥50	0.75	0.94
Wealth | Single man with High educ.	0.48	0.51
Wealth | Single woman age<50	0.35	0.45
Wealth | Single woman age≥50	0.86	0.82
Wealth | Single woman with High educ.	0.51	0.65
Wealth | Married household with husband age<50	1.11	1.07
Wealth | Married household with husband age≥50	1.97	1.92
Wealth | Married household with husband High educ.	1.68	1.55
Wife non-employed and husband non-employed	0.04	0.04
Wife part-time work and husband non-employed	0.02	0.02
Wife full-time work and husband non-employed	0.04	0.03
Wife non-employed and husband full-time work	0.33	0.33
Wife part-time work and husband full-time work	0.29	0.29

Note: Joint labor supply outcomes are summarized for married households in which at least one spouse is under 50 years of age. Wealth is measured in hundreds of thousands of euros. Also see note to Table 10.

Table 12: Internal goodness of fit III: Joint labor supply outcomes in married households, and wealth by household type.

Quantity	Observed	Simulated
Mean wage | Woman	2.42	2.43
Mean wage | Woman & High educ.	2.51	2.51
Mean wage | Woman & High exp.	2.51	2.49
Mean wage | Woman & Spouse High educ.	2.46	2.43
Mean wage | Woman & Youngest child aged<3	2.39	2.45
Mean wage | Woman & 3≤Youngest child aged<6	2.36	2.43
Mean wage | Man	2.75	2.76
Mean wage | Man & High educ.	2.85	2.86
Mean wage | Man & High exp.	2.77	2.80
Mean wage | Man & Spouse high educ.	2.85	2.80
Mean wage | Man & Youngest child aged<3	2.75	2.75
Mean wage | Man & 3 ≤Youngest child aged<6	2.79	2.74
Wage variance | Woman	0.15	0.14
Wage variance | Man	0.15	0.15
Covariance of husband's and wife's wages	0.04	0.04
Mean absolute wage change between $t-2$ and t | Woman and previous wage<2.5	0.41	0.42
Mean absolute wage change between $t-2$ and t | Woman and previous wage≥2.5	0.49	0.49
Mean absolute wage change between $t-2$ and t | Man and previous wage<2.5	0.33	0.38
Mean absolute wage change between $t-2$ and t | Man and previous wage≥2.5	0.51	0.51
Intertemporal wage correlation | Woman	0.11	0.13
Intertemporal wage correlation | Man	0.12	0.12

Note: Wages are in logs. All quantities are computed from observations on employed individuals. In the estimation sample, the wage exclusions (child variables and spouse's education) are jointly significant (p-value<0.01 for women and for men). The note to Table 8 provides further details on the treatment of wages in the estimation procedure.

Table 13: Internal goodness of fit IV: Wages.

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